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FEDERAL AVIATION ADMINISTRATION WASHINGTON D C ASSOC--ETC F/G 1/3
CONSULTATIVE PLANNING CONFERENCE ON AIRCRAFT SEPARATION ASSURAN--ETC(U)
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**U.S. DEPARTMENT OF COMMERCE
National Technical Information Service**

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**Consultative Planning Conference
on Aircraft Separation Assurance:
Presentations**

Federal Aviation Administration Washington D C

27 Sep 76

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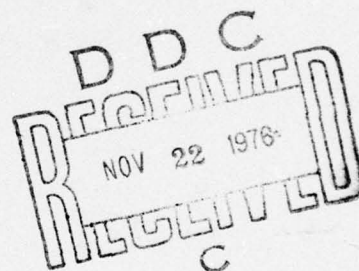
Report No. FAA-ATF-4-76-1

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CONSULTATIVE PLANNING CONFERENCE ON AIRCRAFT SEPARATION ASSURANCE: PRESENTATIONS



September 27, 1976



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**U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Associate Administrator for Air Traffic and Airway Facilities
Washington, D.C. 20590**

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Technical Report Documentation Page

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16. Abstract This document contains the vu-graphs presented at the Consultative Planning Conference of September 27, 1976 on the FAA's Aircraft Separation Assurance Program. The purpose of this conference was to inform and solicit comments from the aviation user groups on the FAA's proposed Aircraft Separation Assurance Program. The first section includes a review and analyses of pertinent statistical information on collisions and collision analyses, major separation assurance objectives, protection priorities, and methods of achieving objectives. The second section, Existing Air Traffic Control System, reviews the procedures and systems being used today related to aircraft separation. The third section, Developmental Approaches, contains information on conflict alert in the terminal environment, Collision Avoidance Systems (CAS) including Airborne CAS (ACAS) and Beacon-Based CAS (BCAS), Intermittent Positive Control (IPC) and Proximity Warning Indicator (PWI) systems. In Comparison of Overlapping Development Programs, the fourth section, information is given concerning FAA's selection of BCAS and IPC as the programs to pursue as well as FAA's decision not to proceed with ACAS and PWI. The final section, the recommended five-point Aircraft Separation Assurance Program, includes the plans, proposed schedules, interrelationships with other programs, cost and present status of (1) conflict alert in the terminal environment, (2) IFR flight Plan requirements (3) transponders and encoding altimeters, (4) BCAS, and (5) IPC.			
17. Key Words Midair Collisions ACAS (Airborne Collision Avoidance Sys) BCAS (Beacon Collision Avoidance Sys) IPC (Intermittent Positive Control) PWI (Proximity Warning Indicator)		18. Distribution Statement Document is available to the public through National Technical Information Service, Springfield, Virginia 22151.	
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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol When You Know Multiply by To Find Symbol

LENGTH

inches 2.5
feet 30
yards 0.9
miles 1.6

AREA

square inches 6.5
square feet 0.09
square yards 0.8
square miles 2.6
acres 0.4

MASS (weight)

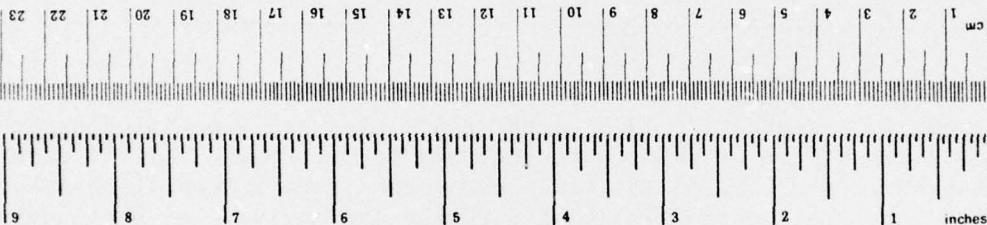
ounces 28
pounds 0.45
short tons (2000 lb) 0.9

VOLUME

teaspoons 5
tablespoons 15
fluid ounces 30
cups 0.24
pints 0.47
quarts 0.95
gallons 3.8
cubic feet 0.03
cubic yards 0.76

TEMPERATURE (exact)

Fahrenheit temperature 5/9 (after subtracting 32) Celsius temperature



Approximate Conversions from Metric Measures

Symbol When You Know Multiply by To Find Symbol

LENGTH

millimeters 0.04
centimeters 0.4
meters 3.3
kilometers 0.6

AREA

square centimeters 0.16
square meters 1.2
square kilometers 0.4
hectares (10,000 m²) 2.5

MASS (weight)

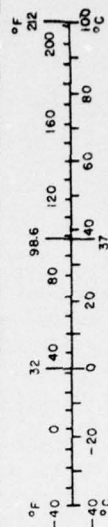
grams 0.035
kilograms 2.2
tonnes (1000 kg) 1.1

VOLUME

milliliters 0.03
liters 2.1
cubic meters 35
cubic meters 1.3

TEMPERATURE (exact)

Celsius temperature 9/5 (then add 32) Fahrenheit temperature



*1 in. = 2.54 exactly. For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.25, 3D Catalog No. C13.10-286.

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AIRCRAFT SEPARATION ASSURANCE

A. BACKGROUND INFORMATION

PROBLEM :

- AS A RESULT OF CONTINUOUS SERIES OF IMPROVEMENTS TO THE ATC SYSTEM, MID AIR COLLISIONS HAVE HISTORICALLY REPRESENTED ONLY A SMALL FRACTION OF CIVIL ACCIDENTS AND FATALITIES
- THE PROBLEM OF PROVIDING COLLISION PROTECTION WITHIN THE ATC SYSTEM FROM UNKNOWN TRAFFIC AND OUTSIDE THE SYSTEM BETWEEN AIRCRAFT NOT AWARE OF EACH OTHERS PRESENCE IS STILL A CONCERN

**SOME SOLUTIONS FOR DEALING WITH THE
PROBLEM OF THE COLLISION POTENTIAL
BETWEEN AN AIRCRAFT IN THE ATC SYSTEM
AND UNKNOWN TRAFFIC**

- **POSITIVE CONTROL AIRSPACE -
EN ROUTE AND TERMINAL**
- **RADAR ADVISORIES**
- **TRANSPONDERS AND ENCODERS**
- **INCREASED FLIGHT VISIBILITY**
- **SPEED REDUCTION**

APPLICATION OF THE SOLUTIONS

POSITIVE CONTROL EN ROUTE - STARTED IN 1958 WITH POSITIVE CONTROL ROUTES. AUGUST 1971 FLOOR OF POSITIVE CONTROL THROUGHOUT U.S. AT 18,000.

TERMINAL CONTROL AREAS - FIRST GROUP I ESTABLISHED JUNE 25, 1970, AT ATLANTA. JANUARY 1, 1974, LAST OF SERIES OF NINE GROUP I TCAS ESTABLISHED AT DALLAS.

FIRST OF GROUP II TCAS ESTABLISHED AT ST. LOUIS. LAST OF SERIES OF 12 GROUP II TCAS ESTABLISHED AT NEW ORLEANS.

RADAR ADVISORY SERVICE - STARTED IN THE EN ROUTE AIRSPACE JANUARY 25, 1959. PROVIDED BY ALL 20 DOMESTIC ARTCCS. PROVIDED BY ALL 171 RADAR APPROACH CONTROL FACILITIES

TERMINAL RADAR SERVICE AREAS - FIRST INTRODUCED IN ATLANTA OCTOBER 1962 PROVIDED AT 69 TERMINAL AREAS 42 GROUP III TCAS DESIGNATED BUT NONE IMPLEMENTED.

TRANSPONDERS & ENCODERS - STARTED USING THE FIRST
64 CODE BEACON SYSTEM IN THE NEW YORK AREA IN
9/10/59.

20 SUCH SYSTEMS INSTALLED BY MAY 1960.

7/1/75 - FAR EFFECTIVE REQUIRING IMPROVED
TRANSPONDERS WITH 4096 CODE CAPABILITY AND
MODE C AUTOMATIC ALTITUDE REPORTING ENCODER
ON ALL FLIGHTS IN CONTROLLED AIRSPACE
ABOVE 12,500 FEET MSL AND GROUP I TCAS.
GROUP II'S TRANSPONDER ONLY. GROUP III'S
TWO WAY RADIO.

INCREASED FLIGHT VISIBILITY - 3/16/58 FAR AMENDED TO
REQUIRED 5 MILES FLIGHT VISIBILITY AND INCREASED
CLOUD CLEARANCE DISTANCE FOR ALL VFR FLIGHTS
ABOVE 10,000 MSL.

SPEED REDUCTION - 12/15/67 FAR AMENDED PROHIBITING
SPEEDS IN EXCESS OF 250 KNOTS BELOW 10,000 MSL.

MAKEUP OF ATC SYSTEM

**20 AIR ROUTE TRAFFIC CONTROL CENTERS
WITH AUTOMATION (CONUS)**

101 LONG RANGE RADARS WITH ATCRBS

426 AIRPORT TRAFFIC CONTROL TOWERS

**156 TERMINAL RADAR SYSTEMS WITH
ATCRBS**

**171 RADAR EQUIPPED APPROACH CONTROL
FACILITIES**

**63 OF THE RADAR EQUIPPED APPROACH
CONTROL FACILITIES EQUIPPED WITH
ARTS III AUTOMATION**

**105 ADDITIONAL RADAR EQUIPPED APPROACH
CONTROL FACILITIES TO BE EQUIPPED
WITH ARTS II TPX42 AUTOMATION**

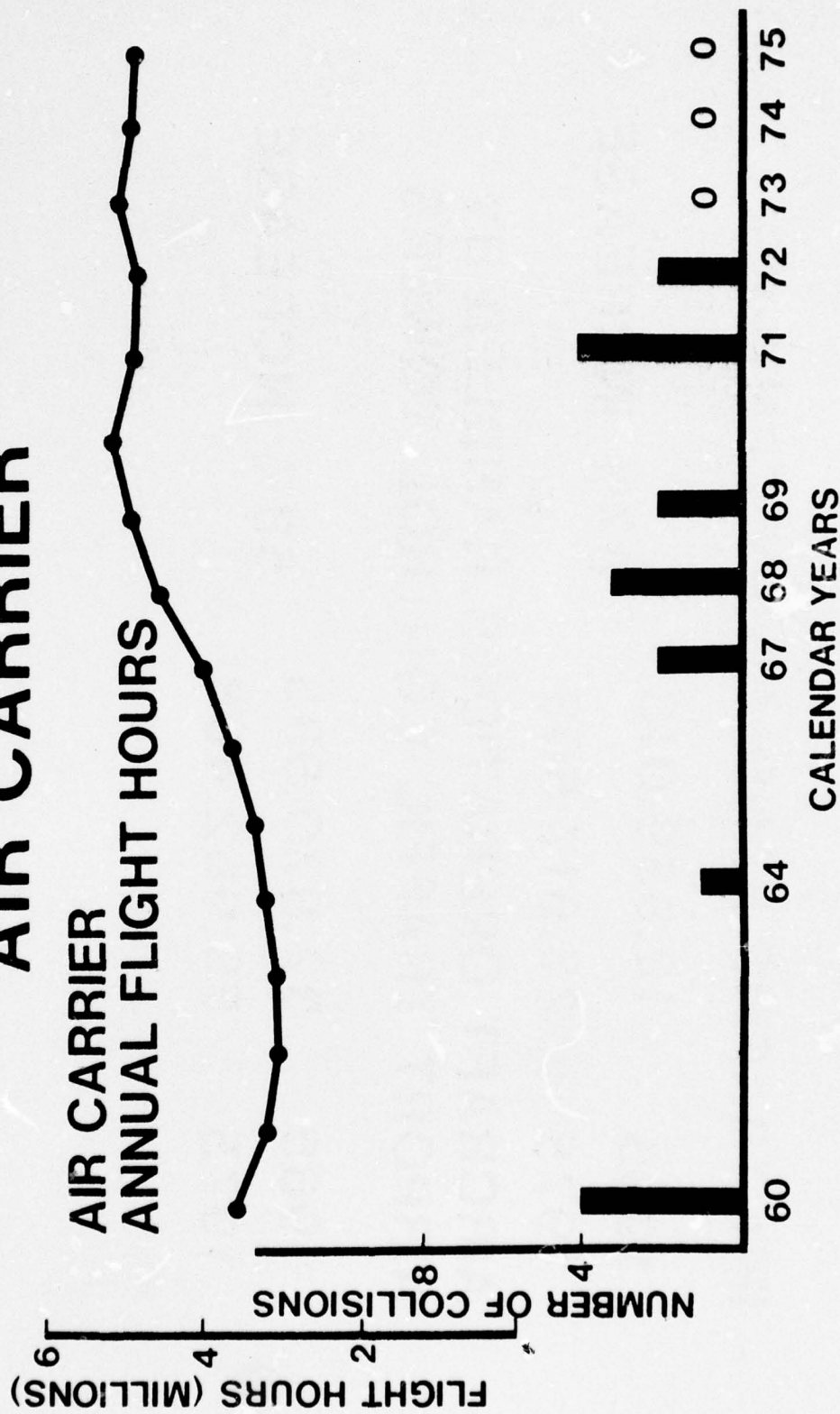
IFR TRAFFIC HANDLED BY CENTERS

1965	12,859,018	87% INCREASE
1975	23,617,503	

**AIRCRAFT OPERATIONS HANDLED BY
AIRPORT TRAFFIC CONTROL TOWERS**

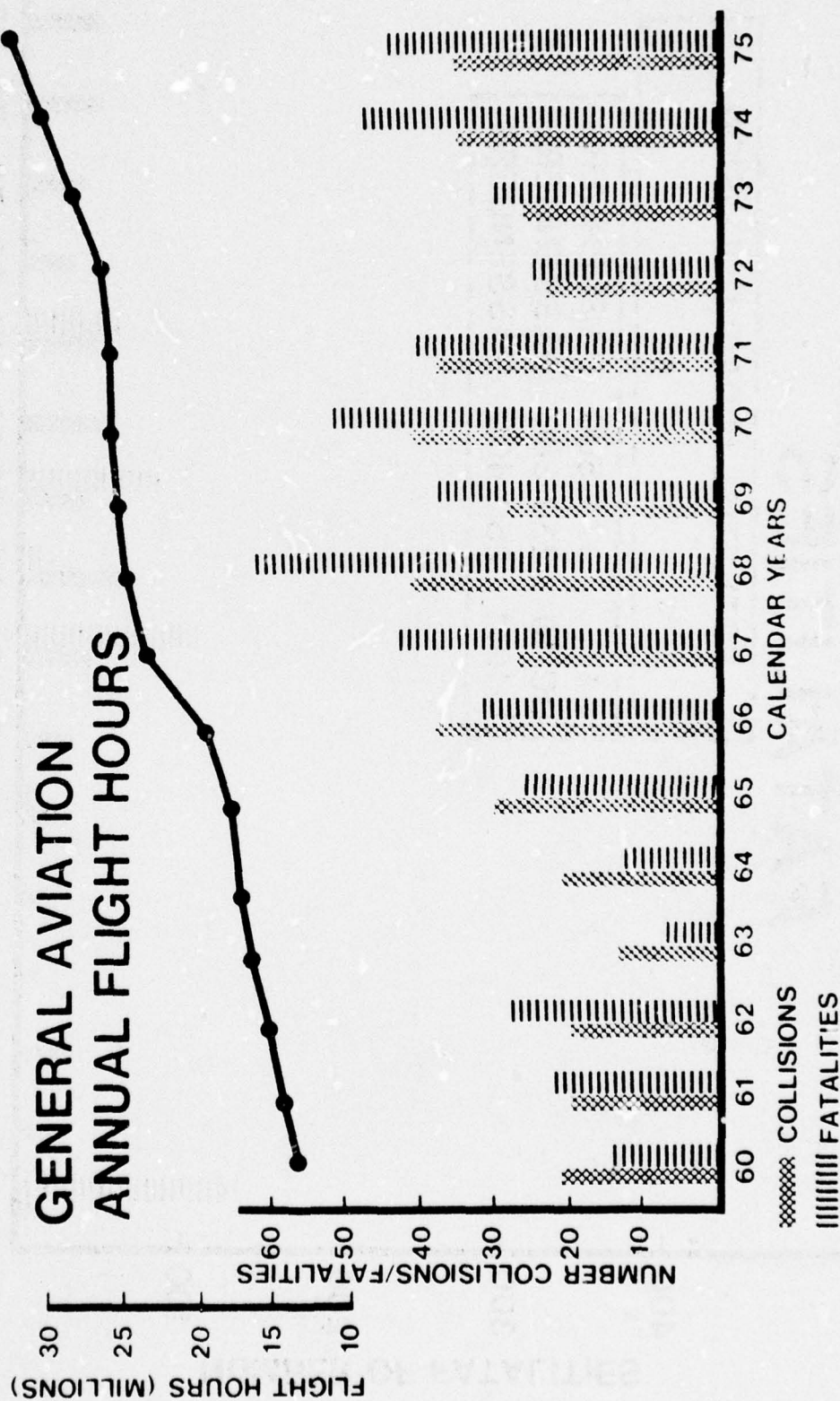
1965	37,870,535	58% INCREASE
1975	59,962,468	

CIVIL AVIATION COLLISIONS INVOLVING AT LEAST ONE AIR CARRIER



CIVIL AVIATION COLLISIONS AND FATALITIES

(NOT INVOLVING AIR CARRIER)



CIVIL AVIATION COLLISION FATALITIES

POTENTIAL MIDAIR COLLISION

NUMBER OF FATALITIES

400

300

200

100

747 374-500 PASSENGERS

DC-10 250-380 PASSENGERS

L-1011 250-400 PASSENGERS

60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75

CALENDER YEARS

NOT INVOLVING AIR CARRIER 513

AIR CARRIER 416

COLLISIONS/FATALITIES BY USER CLASS

JANUARY 1960 - DECEMBER 1975

AIR CARRIER	GENERAL		TOTALS
	CARRIER	MILITARY	
	3/148	1/50	18/416 4%/45%
MILITARY		28/52	28/52 6%/6%
		424/460	424/460 90%/49%
			470/928

CIVIL AVIATION COLLISIONS & FATALITIES JAN. 1960 - DEC. 1975

TOTAL COLLISIONS 470
TOTAL FATALITIES 928

WHERE THEY OCCURRED	SYSTEM CONDITIONS	COLLISIONS	FATALITIES
AT AIRPORTS	NO ATC TOWER	245	163
	ATC TOWER	57	95
IN TERMINAL AREAS	VFR/IFR IFR/IFR	16 2	147 216
EN ROUTE	VFR/VFR VFR/IFR IFR/IFR	144 5 1	242 61 4
		TOTALS: 470	928

COLLISION ANALYSIS - GENERAL

●MANY OF THE COLLISIONS OCCURING OVER THIS FIFTEEN YEAR PERIOD 1960-1975, COULD POSSIBLY HAVE BEEN PREVENTED IF THE ATC SYSTEM HAD POSITIVE IDENTIFICATION ON BOTH AIRCRAFT

●THE PROBLEM OF PROVIDING COLLISION PROTECTION WITHIN THE ATC SYSTEM FROM UNKNOWN TRAFFIC IS STILL A VITAL CONCERN

●THE PROBLEM OF PROVIDING COLLISION PROTECTION BETWEEN AIRCRAFT NOT OPERATING IN THE ATC SYSTEM IS ALSO A VITAL CONCERN

MAJOR OBJECTIVES

- **PROVIDE PROTECTION TO THE GREATEST
NUMBER OF PEOPLE**
- **MINIMIZE THE RESTRICTIONS TO FREEDOM
OF FLIGHT**
- **MINIMIZE REGULATORY RESTRICTION**
- **MINIMIZE AIRSPACE RESTRICTIONS**
- **MINIMIZE NEW AVOINCS COSTS**
- **MINIMIZE IMPLEMENTATION COSTS**

METHODS OF ACHIEVING OBJECTIVES

- **IMPROVE SURVEILLANCE
EFFECTIVENESS**
- **PROVIDE A BACKUP
SEPARATION ASSURANCE
CAPABILITY FOR THE ATC
SYSTEM**

B. EXISTING AIR TRAFFIC CONTROL SYSTEM

A LOOK AT EXISTING ATC SYSTEM

- **SURVEILLANCE**
- **CONTROL TOWERS**
- **AIRSPACE**
- **TRANSPONDER/
ALTITUDE ENCODERS**
- **FLIGHT PLANS**
- **CONFLICT ALERT (EN ROUTE)**

LONG RANGE RADAR (ARSR)

101 SYSTEMS IN PLACE 23 MORE PLANNED

WHEN ALL IN PLACE

GENERAL COVERAGE - 3,000 AGL (CONUS) EXCEPT
FOR MOUNTAINOUS AREAS
7,000 AGL (CONUS) CONTINUOUS

TERMINAL RADAR (ASR)

156 SYSTEMS IN PLACE 44 PLANNED

GENERAL COVERAGE FROM EACH SYSTEM - ABOVE 500 AGL
FOR FIRST 15 MILES - 1,200 AGL
TO 30 MILES BEACON COVERAGE
OUT TO 60 MILES

LONG RANGE RADAR PROGRAM IS ESSENTIALLY COMPLETED.

SURVEILLANCE COVERED AIRPORTS - PASSENGER ENPLANEMENTS

**1974
PASSENGER
ENPLANEMENTS**

PASSENGER AIRPORTS

LARGE AND MEDIUM HUBS

**86 AIRPORTS WITH CAB-CERTIFICATED
AIR CARRIER SERVICE**

87%

SMALL-HUBS

**85 AIRPORTS WITH CAB-CERTIFICATED
AIR CARRIER SERVICE**

9%

NON-HUBS

**SURVEILLANCE AT SOME AIRPORTS WITH
SCHEDULED PASSENGER SERVICE
(AIR CARRIERS OR COMMUTER)**

4%

**AIRPORT TRAFFIC
CONTROL TOWERS ATCT**

**426 ESTABLISHED AS OF
JULY 1976**

459 PLANNED BY 1982

CONTROL TOWER BENEFITS

- **PROVIDES FOR SEPARATION ASSISTANCE TO AIRCRAFT IN THE AIR WITHIN AREA**
- **PROVIDES GROUND, WEATHER AND FLIGHT HAZARD ADVISORIES**
- **PROVIDES SEPARATION SERVICES**
- **RUNWAYS/TAXIWAYS**

POSITIVE CONTROL AIRSPACE

ENROUTE

ALL CONUS AIRSPACE 18,000 TO
60,000 MSL

TERMINAL

9 GROUP I TCAs

12 GROUP II TCAs

42 GROUP III TCAs LOCATIONS IDENTIFIED
BUT NONE IMPLEMENTED

TERMINAL RADAR SERVICE AREAS
(TRSA)

69 DESIGNATED TERMINAL AREAS WITHIN
WHICH STAGE III RADAR SERVICE IS
PROVIDED

SUMMARY

POSITIVE CONTROL AIRSPACE FOR ENROUTE AND TERMINAL TRAFFIC IS AN EFFECTIVE METHOD OF REDUCING THE POTENTIAL OF A MID AIR COLLISION BETWEEN AN AIRCRAFT BEING SERVED BY ATC AND UNKNOWN AIRCRAFT. TERMINAL RADAR SERVICES ARE AREAS ALTHOUGH NOT REGULATORY ARE EFFECTIVE SOLUTIONS FOR DEALING WITH THE PROBLEM.

TRANSPONDERS AND ALTITUDE ENCODERS

- **PRESENTLY REQUIRED FOR
OPERATION ABOVE 12,500
MSL AND IN GROUP I TCA'S**
- **TRANSPONDERS NON-ENCODING
ALTIMETER REQUIRED FOR
GROUP II TCA'S**
- **NOT REQUIRED FOR GROUP III
TCA'S OR TRSA'S**

TRANSPONDER AND ALTITUDE ENCODER EQUIPAGE-PROJECTED

AIRCRAFT CATEGORIES	VOLUNTARY PROJECTED EQUIPAGE 1985		UNEQUIPPED 1985	
	TRANSPONDER	ALTITUDE ENCODER	TRANSPONDER	ALTITUDE ENCODER
PUBLIC AIR TRANSPORTATION	4900 (100%)	4900 (100%)	0	0
FEDERAL AIR TRANSPORTATION	2200 (100%)	2200 (100%)	0	0
PRIVATE AIR TRANSPORTATION	6000 (100%)	6000 (100%)	0	0
OTHER FEDERAL AIRCRAFT	20,000 (100%)	20,000 (100%)	0	0
OTHER GENERAL AVIATION	151,520 (85%)	75,000 (40%)	37,800	113,640
AIRCRAFT WITHOUT AVIONICS	0 (0%)	0 (0%)	36,500	36,500
TOTALS	184,620	108,860	74,380	150,140

TRANSPONDER & ALTITUDE ENCODER - BENEFITS

- **PROVIDES THE THIRD DIMENSION (ALTITUDE)
THEREBY REDUCING COLLISION RISK**
- **BASIS FOR CONFLICT ALERT**
- **BASIS FOR MINIMUM SAFE ALTITUDE
WARNING**
- **IMPROVES THE ABILITY OF THE SYSTEM
TO SEE A TARGET**

TRANSPONDER & ALTITUDE ENCODER - SUMMARY

- **RELATIVELY INEXPENSIVE TO USERS**
- **BASIS FOR SOME ADDITIONAL SERVICES**
- **ALREADY IN WIDESPREAD USE**
- **FOR THE ABOVE REASONS TRANSPONDER AND ALTITUDE ENCODER EQUIPAGE PROVIDE REAL BENEFITS TO THE USERS AND TO THE ATC SYSTEM**

IFR FLIGHT PLANS

CURRENT RULES:

- **REQUIRED FOR IFR OPERATION IN THE ATC SYSTEM**

APPLICATION:

- **MAJOR AIR CARRIERS USE IFR FLIGHT PLANS AS STANDARD ALL PASSENGER FLIGHTS**
- **MOST COMMUTER AIRLINES/AIR TAXIS DO NOT FILE IFR UNDER VFR CONDITIONS**

EXPAND IFR FLIGHT PLAN REQUIREMENTS

BENEFITS:

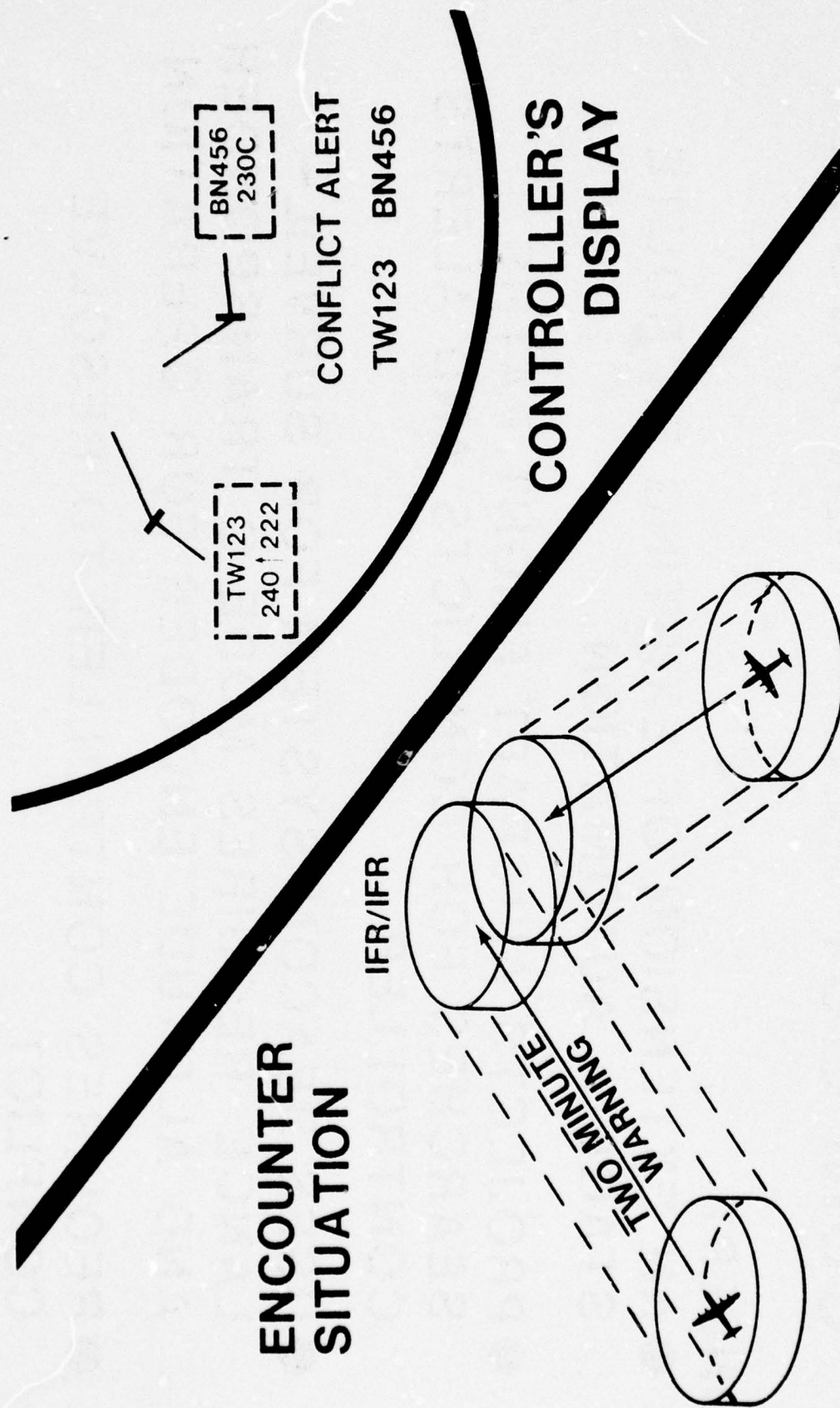
- **SEPARATION SERVICES PROVIDED BY
EXISTING ATC SYSTEM**
- **EXPLOIT FULL RANGE OF PLANNED
ATC SYSTEM ENHANCEMENTS**
- **CONFLICT ALERT**
- **MINIMUM SAFE ALTITUDE WARNING**

CONFLICT ALERT EN ROUTE

CONCEPT

- AN EXTENSION OF EXISTING EN ROUTE STAGE A AUTOMATION
- PROJECTS AIRCRAFT FLIGHT PATHS, SEARCHES FOR CONFLICTS AND ALERTS CONTROLLER
- USES BEACON SYSTEM FOR SURVEILLANCE. REQUIRES MODE C TRANSPONDER AND ALTITUDE ENCODER FOR OPERATION
- REQUIRES CONTROLLER TO RESOLVE CONFLICT

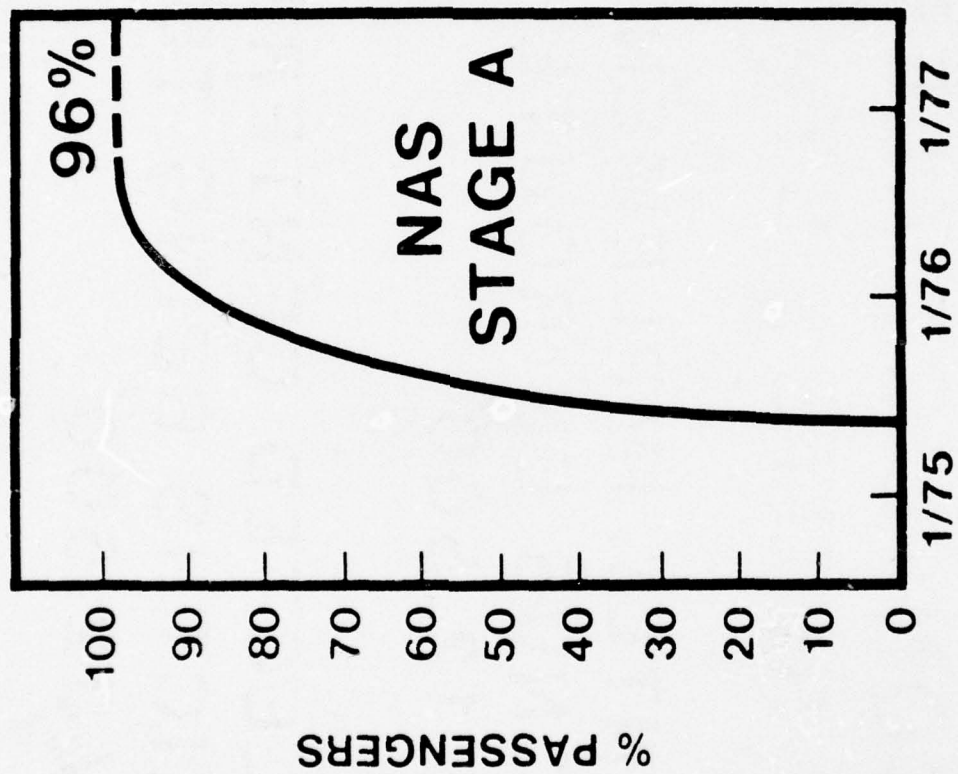
EN ROUTE CONFLICT ALERT



**CONFLICT ALERT
EN ROUTE - STATUS**

- **PRESENTLY IMPLEMENTED AT
ALL CONUS EN ROUTE CENTERS
ABOVE 12,500'**
- **AT SELECTED CENTERS
CONFLICT IS BEING TESTED
BELOW 12,500'**

CONFLICT ALERT(ENROUTE) COVERAGE



CONFLICT ALERT EN ROUTE

- SUMMARY

PRO

- GUARDS AGAINST CONTROLLER DISTRACTION
- NO USER COSTS TO THOSE EQUIPPED WITH TRANSPONDER AND ENCODER
- BUILDS ON EXISTING SYSTEM
- REQUIRES TRANSPONDER AND ALTITUDE ENCODER FOR EFFECTIVE SERVICE
- PROVIDES ONLY ALERT NOT RESOLUTION
- REQUIRES COMMUNICATION LINK AND RESOLUTION VIA CONTROLLER (NOT AUTOMATIC)

CON

- PRESENTLY ONLY WITHIN EN ROUTE SURVEILLANCE COVERAGE AT THE HIGHER ALTITUDES

C. DEVELOPMENTAL APPROACHES

DEVELOPMENTAL APPROACHES TO SEPARATION ASSURANCE

● CONFLICT ALERT (TERMINAL)

**CONTROLLER BACKUP WITHIN
SURVEILLANCE**

● COLLISION AVOIDANCE SYSTEMS CAS)

● AIRBORNE CAS (ACAS)

● BEACON BASED CAS (BCAS)

● INTERMITTENT POSITIVE CONTROL (IPC)

● PROXIMITY WARNING INDICATOR (PWI) SYSTEMS

MIDAIR COLLISION STATISTICS

SUMMARY 10 YRS

AVERAGES: 29 COLLISIONS/60 FATALITIES ANNUALLY
5% CIVIL AVIATION FATALITIES
13% PUBLIC AIR CARRIER FATALITIES

WHO:	1 AIR CARRIER	30 FATALITIES
	1 MILITARY	
	27 GENERAL AVIATION	30 FATALITIES

WHERE: 33% ACCIDENTS/75% FATALITIES WITHIN
SURVEILLANCE

7%/15%	EN ROUTE
30%/62%	TERMINAL
54%/17%	AIRPORT

SENSITIVITY: FIFTEEN YRS: 417 PAT FATALITIES FROM
MIDAIRS - 18 ACCIDENTS
ONE JUMBO WOULD DOUBLE THIS IN
ONE EVENT

DEVELOPMENT APPROACHES

- **NO SINGLE PANACEA EXISTS**
- **ALL SYSTEMS HAVE LIMITATIONS**
 - **PERFORMANCE**
 - **COVERAGE**
 - **COST**
 - **AVAILABILITY**
- **NEED PROPER MIX**
- **VOLUNTARY APPROACH WHERE POSSIBLE**

CONFLICT ALERT - TERMINAL

- **SIMILAR TO ENROUTE SYSTEM**
 - **CONTROLLER AID WITHIN COVERAGE**
 - **ARTS III LOCATIONS**
- HIGHEST DENSITIES**
- **TRIGGERS ON TRANSPONDERS AND ENCODERS**
 - **UNIVAC DEVELOPMENT**

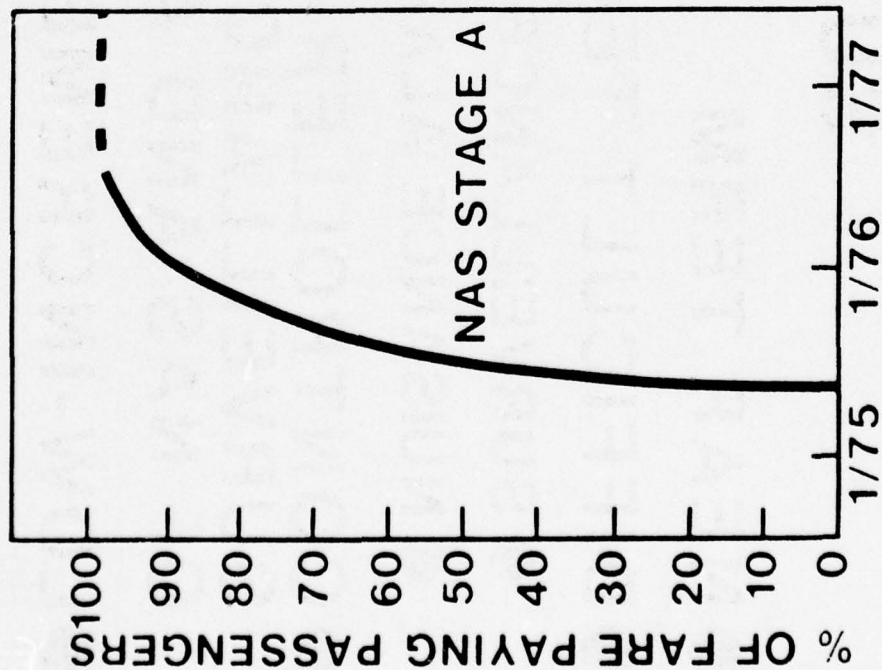
CONFLICT ALERT TERMINAL PRO/CONS

**SAME AS FOR ENROUTE CONFLICT ALERT PLUS THE FOLLOWING
DEVELOPMENTAL PROBLEMS:**

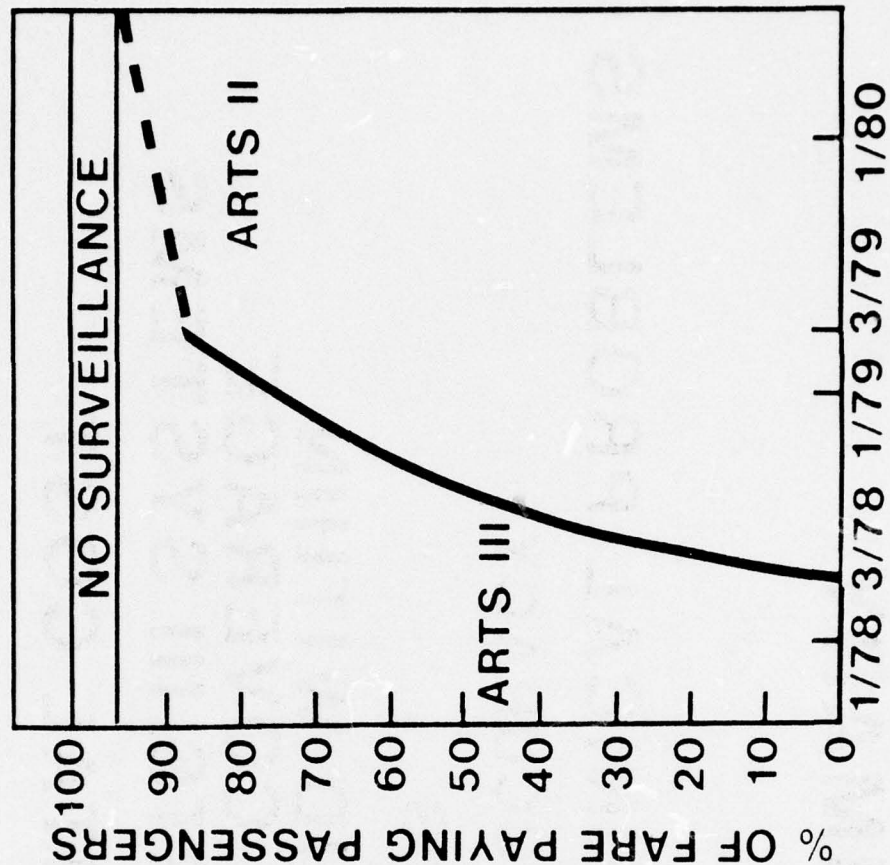
- **REQUIRES MORE ACCURATE SURVEILLANCE BECAUSE OF
TURNING AIRCRAFT**
- **IF TRANSPONDERS AND ALTITUDE ENCODERS NOT
REQUIRED OPERATIONAL EFFECTIVENESS REDUCED**
- **PREDICTION OF AIRCRAFT FLIGHT INTENT MUCH MORE
DIFFICULT IN TERMINAL AREAS (TURNING MANEUVERS)**
- **UPGRADING ARTS II WITH BEACON TRACKING TO SUPPORT
CONFLICT ALERT**
- **COMPUTER MEMORY AND INPUT/OUTPUT PROCESSOR MAY
HAVE TO BE ADDED TO ARTS III**

CONFLICT ALERT - COVERAGE

ENROUTE SERVICE



PLANNED TERMINAL SERVICE



TERMINAL CONFLICT ALERT SUMMARY

- **NEAR TERM**
- **DIFFICULT TECHNICAL PROBLEMS**
 - **SURVEILLANCE ACCURACY**
 - **NUISANCE ALARMS**
- **CONTROLLER AID WITHIN
SURVEILLANCE-COVERAGE
OF NAS AND ARTS III SYSTEMS**
- **LOW-INCREMENTAL COST**
- **NO PILOT INFORMATION**

INDEPENDENT COLLISION AVOIDANCE SYSTEMS

● **ACAS**

● **BCAS**

ACAS HISTORY

- **NEED RECOGNIZED IN LATE 50'S
BY AIRLINES**
- **ATA CAS DEVELOPMENT**
- **COLLISION PREVENTION
ADVISORY GROUP**
- **CONGRESSIONAL BILLS (3 HOUSE
AND 2 SENATE)**
- **FAA COMMITMENT TO CONGRESS
TO TEST 3 ACAS**
- **FAA TEST PROGRAM**

ACAS DESIGNS

MANUFACTURER	NAME	TYPE
MCDONNELL-DOUGLAS	ELIMINATE RANGE ZERO SYSTEM (EROS)	TIME/ FREQUENCY
RCA	SEPARATION CONTROL OF AIRCRAFT BY NONSYNCHRONOUS TECHNIQUES (SECANT)	INTERROGATE/ TRANSPONDER
HONEYWELL	AVIONIC OBSERVATION OF INTRUDER DANGER SYSTEM (AVOIDS)	INTERROGATE/ TRANSPONDER

ACAS COMMON FEATURES

- ALL ARE COOPERATIVE (REQUIRE SIMILAR AVIONICS ON OTHER AIRCRAFT FOR THE SOLE PURPOSE OF CAS)
- ALL AIR CARRIER VERSIONS USE SAME DISPLAY (MODIFIED INSTANTANEOUS VERTICAL SPEED INDICATOR)
- ALL OBTAIN ALTITUDE INPUT FROM ALTITUDE ENCODER
- ALL SYSTEMS HAVE LESS EXPENSIVE GENERAL AVIATION VERSION
- INFORMATION AVAILABLE TO SYSTEM IS RANGE AND ALTITUDE
- SYSTEMS GENERATE VERTICAL ESCAPE MANEUVERS ONLY (UP, DOWN, LEVEL OFF)
- ALL OPERATE IN 1592.5 – 1622.5 MHZ FREQUENCY BAND
- ALL USE SAME COLLISION AVOIDANCE LOGIC – AIR NAVIGATION AND TRAFFIC CONTROL REPORT NO. 117 (ANTC 117)

TIME/FREQUENCY CONCEPT



SYNCHRONIZATION

- DATA LINK CAPABILITY BETWEEN EQUIPPED AIRCRAFT
- OPERATES AT FOUR FREQUENCIES, 1600, 1605, 1610, 1615
- REQUIRES GROUND STATIONS

AVOIDS CONCEPT



- ONE FREQUENCY
- COMPLETELY INDEPENDENT OF GROUND

SECANT CONCEPT



- 24 FREQUENCIES DEPENDING ON ALTITUDE
- DATA LINK CAPABILITY BETWEEN EQUIPPED AIRCRAFT
- COMPLETELY INDEPENDENT OF GROUND

EXTENT OF ACAS TEST PROGRAM

FLIGHT TESTS

- ACTUAL ENCOUNTERS WERE FLOWN UTILIZING CAS DISPLAYS
- BOTH TWO & THREE AIRCRAFT ENCOUNTERS WERE FLOWN
- COMMUNICATION LINK RELIABILITY WAS MEASURED
- THE ABILITY TO MEASURE RANGE AND RANGE RATE WAS VERIFIED ALONG WITH ITS ASSOCIATED ACCURACY

BENCH TESTS

- TARGETS WERE GENERATED AND THE ABILITY OF THE EQUIPMENT TO TRACK AIRCRAFT WAS ESTABLISHED
- HIGH LEVELS OF FRUIT WERE ADDED TO CHECK EQUIPMENT PERFORMANCE
- ELECTRONIC PARAMETERS WERE VERIFIED

ACAS TEST PROGRAM

SIMULATIONS AND ANALYSES

- **FUTURE DENSITIES MODELED**
- **ERROR ANALYSIS**
- **CAS COMPATIBILITY USING ACTUAL ARTSIII TAPES**
- **CAS ESCAPE LOGIC**

ACAS FLIGHT TEST PROGRAM

- ACCEPTANCE OF EQUIPMENT
- AIR CARRIER VERSION
- GENERAL AVIATION VERSION
- COMPLETE AIR CARRIER VERSION EQUIPMENT
- FINAL REPORT
- COMPLETE GENERAL AVIATION FLIGHT TESTS
- FINAL REPORT

HONEYWELL	MCDONNELL-DOUGLAS	RCA
JAN. 74 APRIL 75	OCT. 74 OCT. 74	MAY 73 OCT. 75
OCT. 74 MAY 75	OCT. 75 SEPT. 76	MARCH 74 NOV. 74
OCT. 75 SEPT. 76	OCT. 75 SEPT. 76	DEC. 75 SEPT. 76

ACAS TEST PROGRAM

PARTICIPANTS

ACTIVITY

**NAVAL AIR
DEVELOPMENT
CENTER**

**TEST & EVALUATION OF RCA
& HONEYWELL AIR CARRIER
& GENERAL AVIATION ACAS
SYSTEMS**

NAFEC

**TEST & EVALUATION OF
MCDONNELL-DOUGLAS AIR
CARRIER & GENERAL
AVIATION ACAS SYSTEMS**

IDA

**THEORETICAL ANALYSIS OF
ACAS SYSTEMS CAPABILITIES**

**ALL TESTS CONDUCTED UNDER FAA
SUPERVISION**

ACAS OPERATIONAL CONCERNS

- **ACAS/ATC INTERACTION**

- **NUISANCE ALARMS**

- **UNPLANNED MANEUVERS**

ACAS ASSESSMENT

● TECHNICAL

● OPERATIONAL

● COST

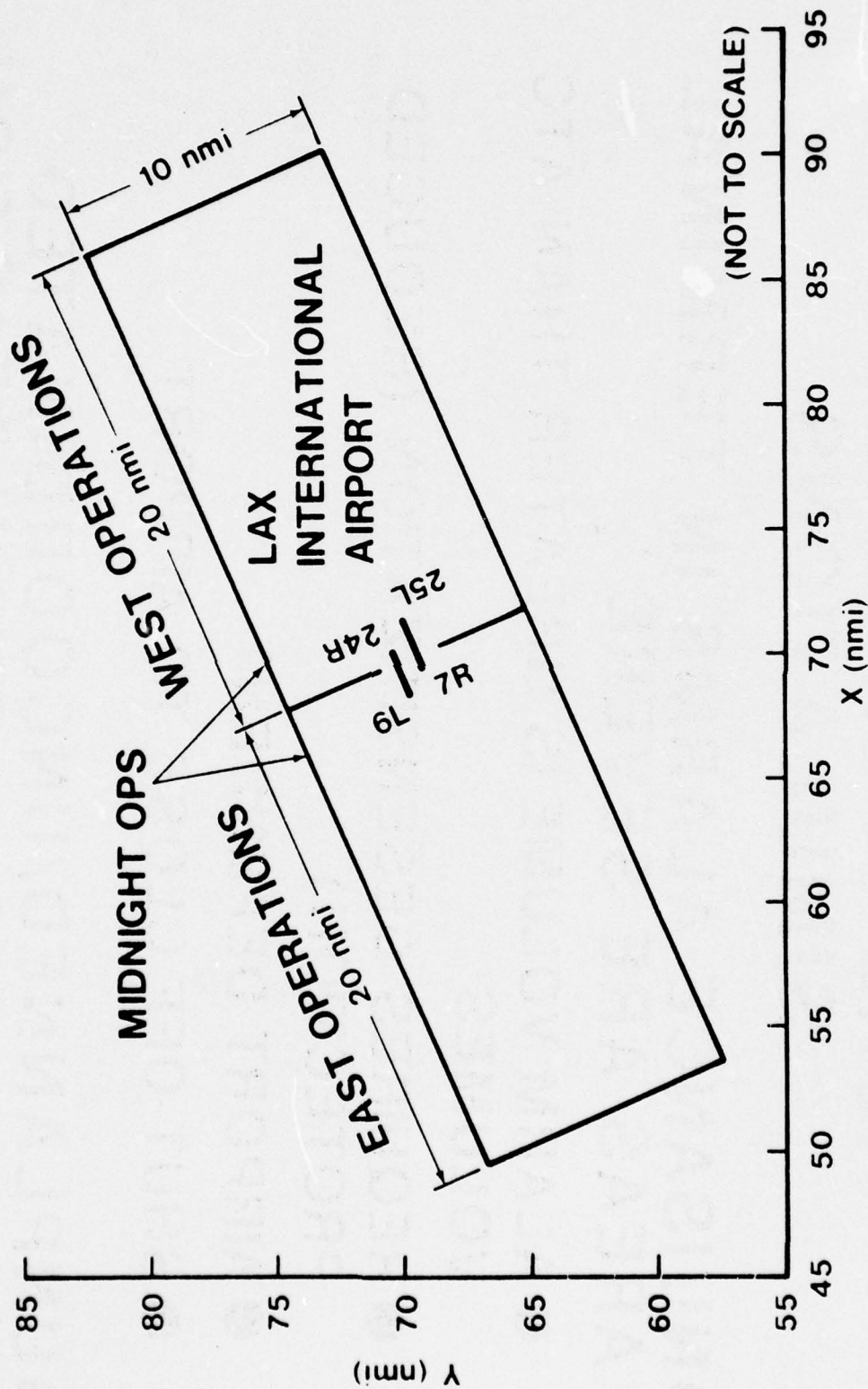
ACAS TECHNICAL TEST RESULTS

	HONEYWELL	MCDONNELL- DOUGLAS	RCA
COMMUNICATION RELIABILITY AT MAXIMUM WARNING RANGE	EXCELLENT	EXCELLENT	GOOD
WARNING TIME ACCURACY (R/R INDEX)	BEST	GOOD	GOOD
CAN COMMUNICATE IN 1985 (L.A. BASIN MODEL) WITH ALL AIRCRAFT ACAS EQUIPPED?	YES	YES	NO
INTERFERENCE SUSCEPTIBILITY TO RADAR ALTIMETERS	BEST	WORST	MEDIUM
DEGREE OF DESIGN MATURITY	HIGH	MEDIUM TO HIGH	LOW

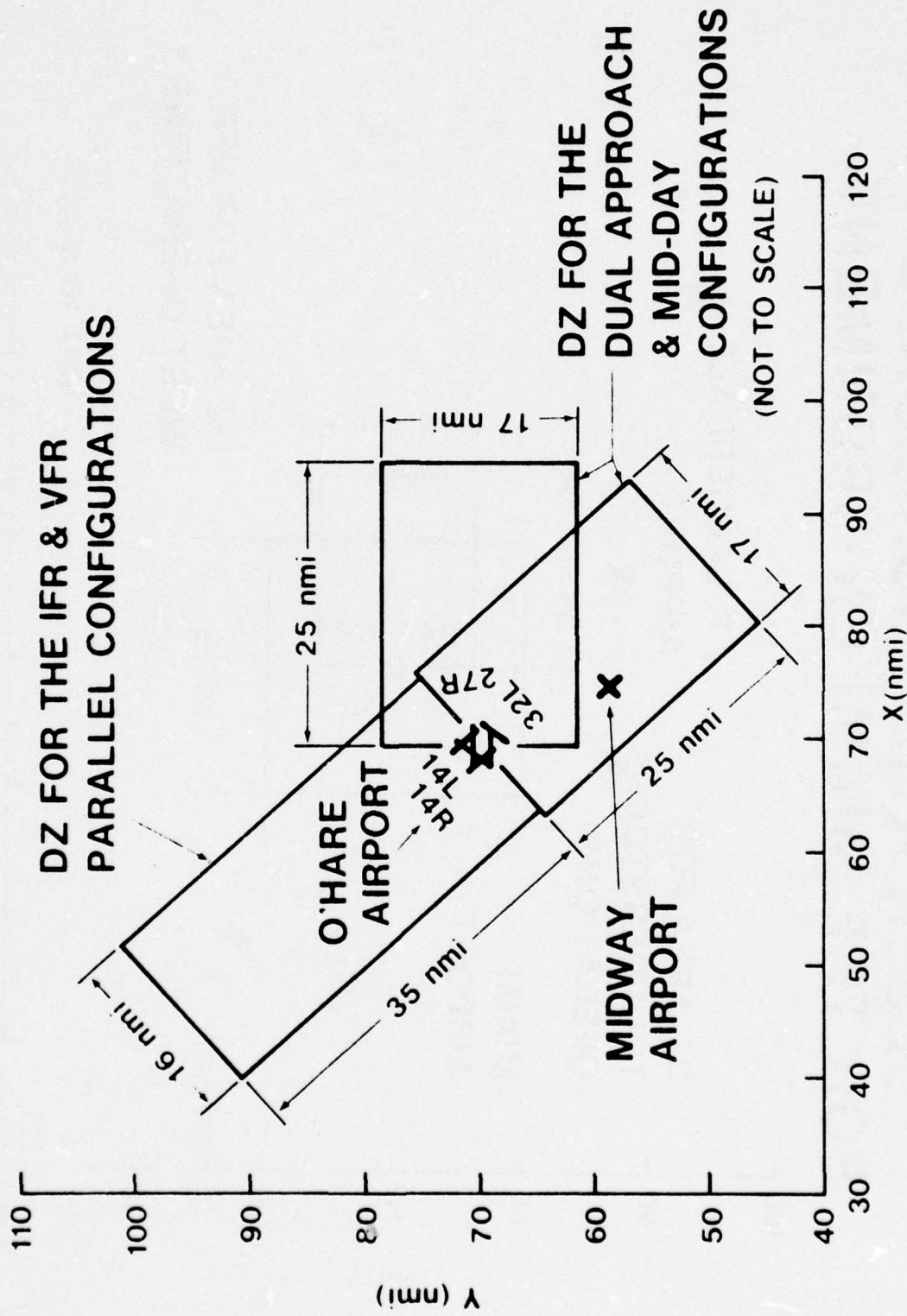
ACAS OPERATIONAL SIMULATIONS

- **NUISANCE ALARMS IN TERMINAL
AREAS ARE SEVERE**
- **ALARM VOLUME IS GREATER THAN ATC
VOLUMES**
- **REQUIRES DESENSITIZATION (REDUCED
PROTECTION)**
- **AIRPORT DEPENDENT**
- **SHUT-OFF CLOSE TO AIRPORT**
- **UNPLANNED/UNCOORDINATED
MANEUVERS --- CHAIN REACTION
IS A CONCERN**

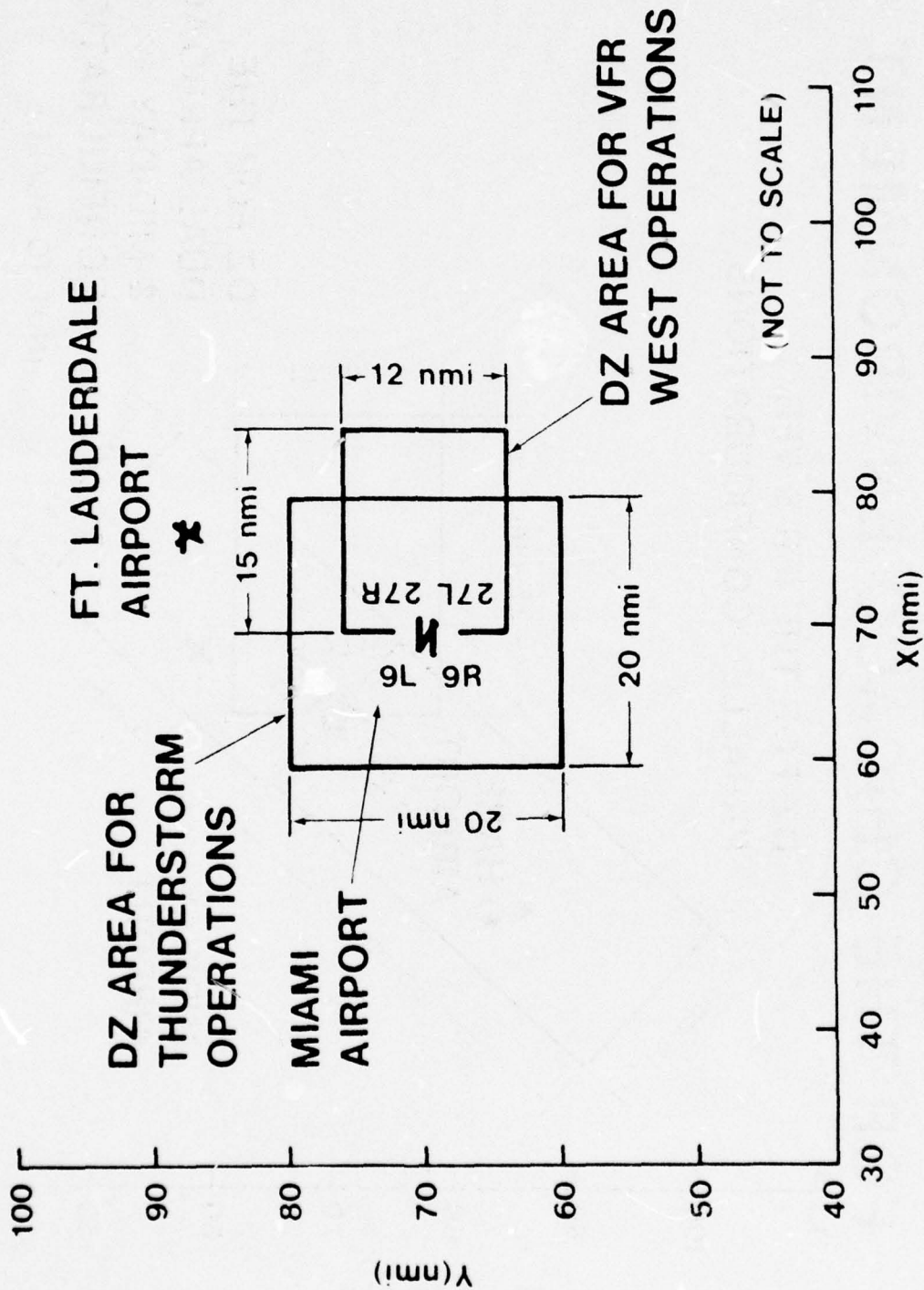
DESENSITIZATION ZONES FOR THE LOS ANGELES ENVIRONMENT



DESENSITIZATION ZONES FOR THE CHICAGO ENVIRONMENT



DESENSITIZATION ZONES FOR THE MIAMI ENVIRONMENT



ACAS COSTING ANALYSIS

- ALL ACAS COSTING WAS DONE BY ARINC RESEARCH CORPORATION
- BOTH AIR CARRIER AND GENERAL AVIATION VERSIONS OF THE THREE COMPETING ACAS SYSTEMS WERE COSTED
- ARINC OBTAINED BOTH THE FINAL DESIGNS AND THE MANUFACTURER'S COST ESTIMATE, AND THEN CRITIQUED AND DEVELOPED THEIR OWN COSTS
- GENERAL AVIATION ELECTRONIC COSTS WERE VERIFIED BY BOTH NARCO AND GENAVE, TWO GENERAL AVIATION ELECTRONICS PRODUCERS
- DOD COSTS WERE VERIFIED BY DOD
- AIR CARRIER INSTALLATION COSTS WERE OBTAINED FROM THE AIRLINES
- GENERAL AVIATION INSTALLATION COSTS WERE OBTAINED FROM A SURVEY OF GENERAL AVIATION REPAIR AND INSTALLATION SHOPS

ACAS AVIONIC COSTS

AIR CARRIER	HONEYWELL	MCDONNELL	RCA
BOX (1)	\$4,012	\$4,694	\$5,501
DISPLAY (2)	1,092	1,092	1,092
CONTROL (1)			127
ANTENNA (2)	63	63	63
TOTAL	\$6,322	\$7,004	\$7,938

NOTES: () INDICATE NUMBER OF UNITS REQUIRED
AND ARE REFLECTED IN BOTTOM TOTAL

ACAS AVIONIC COSTS

GENERAL AVIATION	HONEYWELL		MCDONNELL		RCA	
	WITHOUT ALTITUDE ENCODER	WITH ALTITUDE ENCODER	WITHOUT ALTITUDE ENCODER	WITH ALTITUDE ENCODER	WITHOUT ALTITUDE ENCODER	WITH ALTITUDE ENCODER
BOX WITH DISPLAY (1)	904	1,161	1,584	1,820	1,837	2,073
ANTENNA	13 (2)	13 (2)	13 (1)	13 (1)	13 (1)	13 (1)
TOTAL	\$930	\$1,186	\$1,597	\$1,833	\$1,850	\$2,086

NOTES: () INDICATE NUMBER OF UNITS REQUIRED AND ARE REFLECTED IN
BOTTOM TOTAL

GENERAL AVIATION COSTS ARE SELLING PRICE WHICH IS LIST PRICE
LESS 20% DISCOUNT

ACAS IMPLEMENTATION ASSUMPTIONS

CATEGORIES OF AIRCRAFT	TYPE OF AVIONICS [*]	
	AIR CARRIER	GENERAL AVIATION
AIR CARRIER	▲	
LARGE GENERAL AVIATION	▲	
SMALL GENERAL AVIATION		▲
MILITARY HI PERFORMANCE	▲	
MILITARY LO PERFORMANCE		▲

^{*}IN ALL CASES SINGLE SYSTEM INSTALLATION
IS ASSUMED

ACAS INSTALLATION COSTS

AIR CARRIER TYPE	\$4227*
AIRCRAFT	
LARGE GENERAL AVIATION	\$1925
AIRCRAFT	
SMALL GENERAL AVIATION	\$ 226
AIRCRAFT	
MILITARY HI PERFORMANCE	\$8252*
AIRCRAFT	
MILITARY LO PERFORMANCE	\$2479*
AIRCRAFT	

* THESE COSTS DO NOT INCLUDE
NONRECURRING COSTS UNIQUE TO
BOTH DOD AND THE AIRLINES

ACAS MAINTENANCE COSTS

FIGURES ARE COST PER AIRCRAFT PER YEAR BASED ON
AIRCRAFT USAGE AND ELECTRONICS RELIABILITY


	HONEYWELL	MCDONNELL- DOUGLAS	RCA
AIR CARRIER	\$337	\$302	\$358
LARGE GENERAL AVIATION AIRCRAFT	\$22	\$19	\$24
SMALL GENERAL AVIATION AIRCRAFT	\$23	\$39	\$32
HI PERFORMANCE DOD	\$781	\$767	\$776
LO PERFORMANCE DOD	\$882	\$952	\$918

ACAS NONRECURRING COSTS*

	HONEYWELL	MCDONNELL	RCA
AIR CARRIER	\$103	\$160	\$164
LARGE GENERAL AVIATION	\$ 0	\$ 0	\$ 0
SMALL GENERAL AVIATION	\$ 0	\$ 0	\$ 0
MILITARY HI PERFORMANCE	\$ 391	\$ 514	\$ 471
MILITARY LO PERFORMANCE	\$ 100	\$ 208	\$ 196

*DOCUMENTATION COSTS, ONE TIME ENGINEERING COSTS, SPARES, ETC.

ACAS AVIONICS LIFE CYCLE COSTS

AIRCRAFT CATEGORIES FOR SEPARATION ASSURANCE	FLEET SIZE 1985	% EXPECTED TO EQUIP	COST		
			HONEYWELL	MDEC	RCA
PUBLIC AIR TRANSPORTATION	4,900	100	\$ 56 M	\$ 59 M	\$ 65 M
FEDERAL AIR TRANSPORTATION	2,200	100	\$ 22 M	\$ 24 M	\$ 24 M
PRIVATE AIR TRANSPORTATION	6,000	100	\$ 49 M	\$ 54 M	\$ 60 M
OTHER FEDERAL AIRCRAFT	20,000	100	\$229 M	\$244 M	\$254 M
OTHER GENERAL AVIATION	189,400	100	\$277 M	\$413 M	\$459 M
AIRCRAFT WITHOUT AVIONICS	36,500	0	0	0	0
TOTAL	259,000		\$633 M	\$794 M	\$862 M

NOTE: THESE COST INCLUDE ELECTRONICS, INSTALLATION, NONRECURRING COSTS,
MAINTENANCE COSTS AND THE COST OF AN ENCODER

ACAS GROUND COSTS

- **OPERATION OF THE MCDONNELL-DOUGLAS SYSTEM WILL REQUIRE THE OPERATION OF 5 GROUND SYNCHRONIZING STATIONS, AT AN INVESTMENT COST OF ABOUT \$1.5M AND A YEARLY OPERATIONS/ MAINTENANCE COST (NOT ESTIMATED)**
- **NEITHER THE HONEYWELL OR RCA SYSTEMS REQUIRE GROUND STATIONS**

ADDITIONAL COST

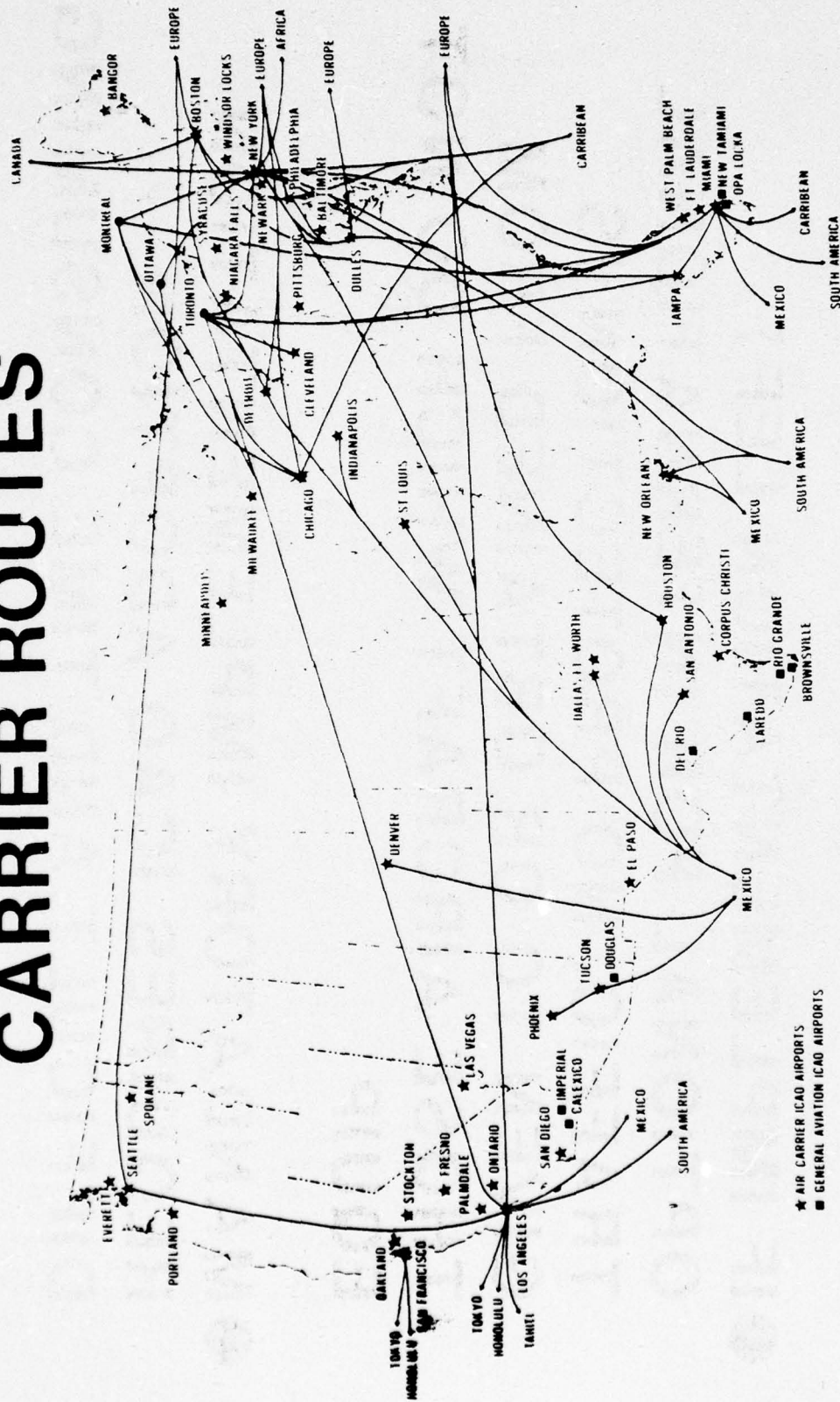
RADAR ALTIMETER INTERFERENCE

- RADAR ALTIMETERS OPERATE ON THE SAME FREQUENCY AS ACAS
- TESTS TO DATE INDICATE THAT RADAR ALTIMETERS DO INTERFERE WITH THE ACAS EQUIPMENTS TESTED
- VULNERABILITY TO INTERFERENCE IS LEAST WITH HONEYWELL AND HIGHEST WITH McDONNELL-DOUGLAS
- THE BONZER TRN-70 RADAR ALTIMETER IS THE WORST OFFENDER AND THE MOST NUMEROUS GENERAL AVIATION TYPE
- TESTS SHOW EXCESSIVE INTERFERENCE BETWEEN RADAR ALTIMETERS AND ACAS ON THE SAME AIRFRAME
- RETUNING OF RADAR ALTIMETERS TO THE PREVENT/REDUCE INTERFERENCE APPEARS IMPRACTICAL
- FAA RECOMMENDS EXCLUSION OF RADAR ALTIMETERS FROM THE ACAS FREQUENCY BAND AT THE COST OF \$85 MILLION TO DOD AND \$1 MILLION TO GENERAL AVIATION

INTERNATIONAL CONCERNS

- **IF IMPLEMENTATION LEFT
OPTIONAL FOR INTERNATIONAL
TRAFFIC, NO PROTECTION IS
GIVEN TO OR OBTAINED FROM
THOSE AIRCRAFT WHICH DO NOT
EQUIP**
- **MANDATORY IMPLEMENTATION
REQUIRES ICAO ADOPTION ---
DIFFICULT AND TIME CONSUMING**

INTERNATIONAL AIR CARRIER ROUTES



ACAS ASSESSMENT

- **MINNEAPOLIS-HONEYWELL IS CLEARLY BEST ACAS SYSTEM AVAILABLE**
- **GOOD SERVICE OUTSIDE OF TERMINAL AREAS PROTECTION LIMITED IN TERMINAL REGIONS**
- **FULL PROTECTION REQUIRES MANDATORY IMPLEMENTATION**
 - \$719 M
- **INTERNATIONAL PROTECTION IS DIFFICULT**

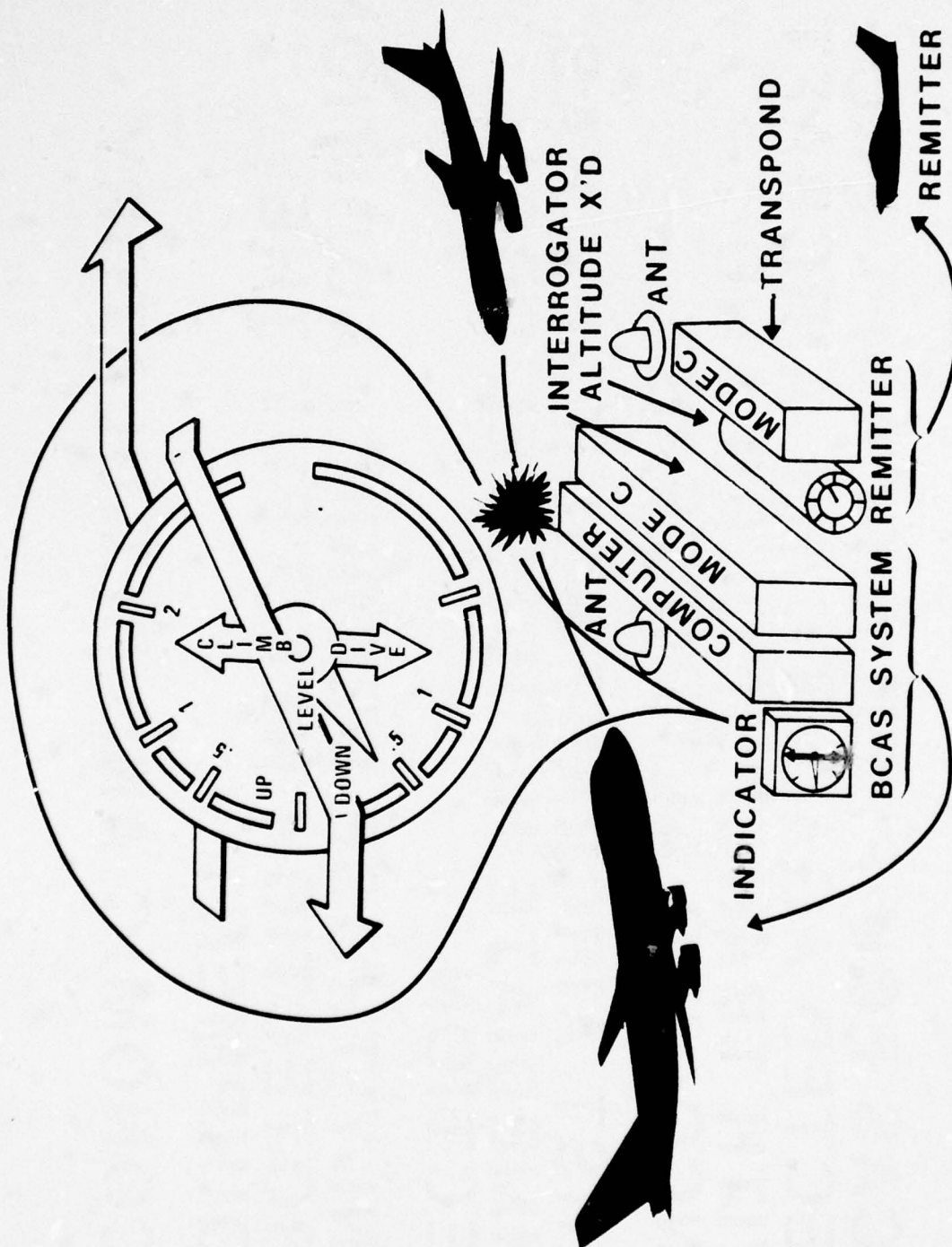
BCAS

**AN ACAS UTILIZING THE
ATCRBS OR DABS BEACON
TRANSPONDER, WITH
ALTITUDE ENCODING, AND
ASSOCIATED SIGNAL
STRUCTURE**

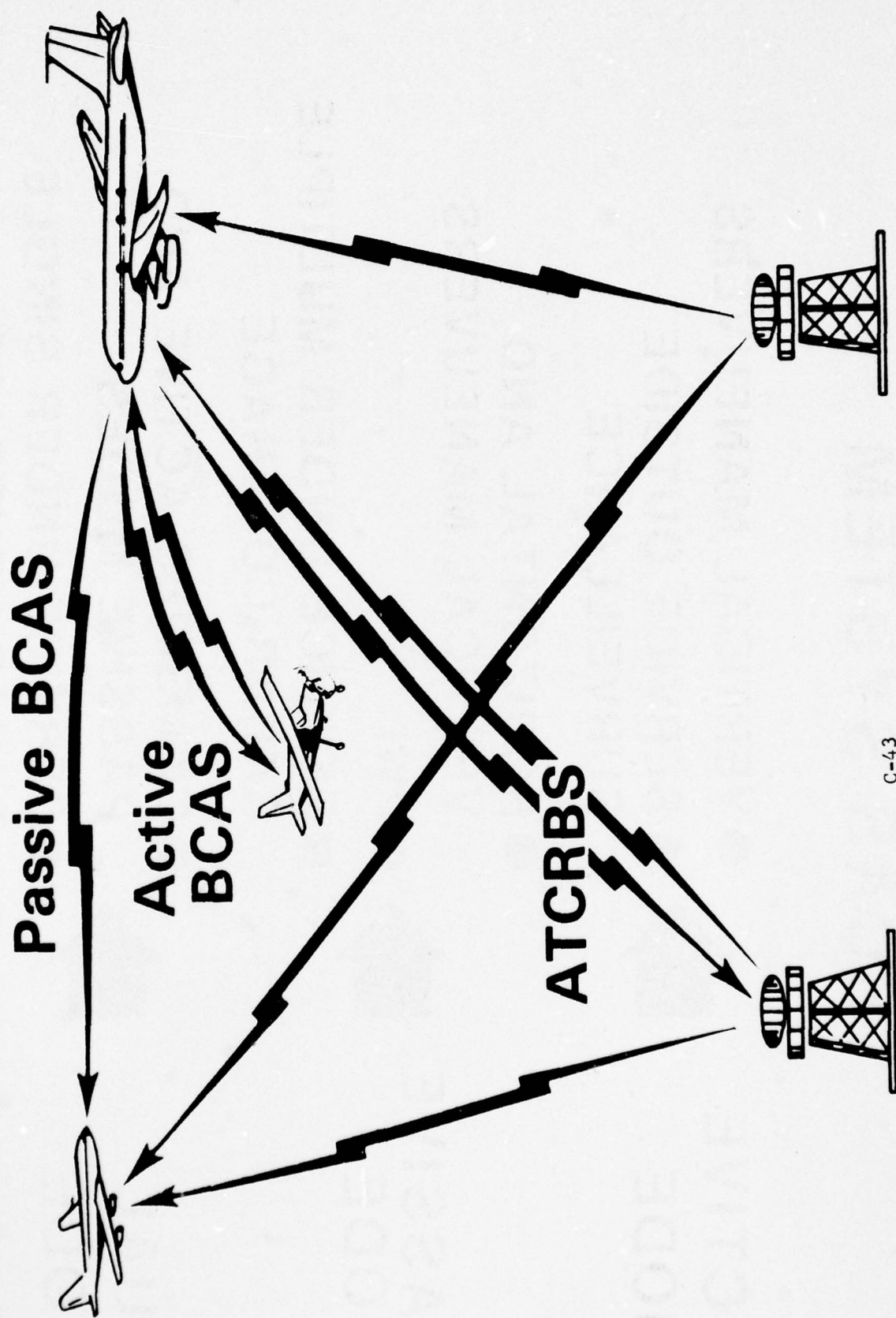
BCAS

- **BCAS EQUIPPED AIRCRAFT PROTECTED AGAINST ALL AIRCRAFT WITH TRANSPONDERS AND ENCODING ALTIMETERS**
- **FIRST AIRCRAFT EQUIPPED HAS IMMEDIATE HIGH LEVEL PROTECTION**
- **ONLY THOSE DESIRING ADDITIONAL PROTECTION NEED BUY THE EQUIPMENT**
- **ECONOMIC AND REGULATORY**

BCAS DESCRIPTION



BCAS Concept



BCAS SYSTEM

ACTIVE MODE



- VERTICAL MANEUVERS
- SERVICE OUTSIDE SURVEILLANCE

PASSIVE MODE



- HORIZONTAL AND VERTICAL MANEUVERS
- PWI
- SERVICE UNDER MULTIPLE RADAR COVERAGE

DUAL MODE



- COMBINES ACTIVE AND PASSIVE MODES
- SERVICE UNDER SINGLE RADAR COVERAGE

BCAS HISTORY

- 1968 G. LITCHFORD PROPOSED A PWI UTILIZING ATCRBS
- 1972 USAF AWARDED CONTRACT TO LITCHFORD TO DEMONSTRATE
CONCEPT FEASIBILITY OF SSR -- CAS TECHNIQUE
- 1973 SSR -- CAS DEMONSTRATED ON GROUND AT LAGUARDIA, N.Y.
AIRPORT. FAA SUGGESTED THAT AN ACTIVE MODE BE ADDED
TO SSR -- CAS
- 1974 SSR -- CAS DEMONSTRATED ON PAN AM BUILDING, N.Y. CITY
FAA CONDUCTED TECHNICAL ANALYSIS OF SSR -- CAS
FAA DEVELOPED CONCEPT OF PURELY ACTIVE BCAS
- 1975 FAA PROCEEDED TO DEVELOP ACTIVE BCAS
CONTRACT AWARDED TO LITCHFORD FOR DELIVERY
OF HIS ACTIVE/PASSIVE (SSR -- CAS) BCAS SYSTEM

BCAS STATUS

- **CONCEPT FEASIBILITY OF BOTH PASSIVE/ACTIVE AND ACTIVE SYSTEM DEMONSTRATED**
- **DEVELOPMENT PROGRAM UNDERWAY**
- **FEASIBILITY MODELS OF BOTH ACTIVE AND PASSIVE/ACTIVE PRESENTLY FLYING AT NAFEC**
- **DRAFT ENGINEERING REQUIREMENT AVAILABLE FOR BOTH ACTIVE AND PASSIVE/ACTIVE SYSTEM**
- **REQUEST FOR PROPOSAL FOR PROTOTYPES PLANNED FOR MARCH 77**

COMPARISON OF ACAS & BCAS

	ACAS	BCAS
1. LIMITATIONS	DENSE TERMINAL AREAS	DENSE TERMINAL AREAS
2. SERVICE AREAS	CONUS	WORLDWIDE
3. INFORMATION AVAILABLE TO SYSTEM	RANGE AND ALTITUDE	RANGE, ALTITUDE, BEARING (PASSIVE MODE)
4. MANEUVER COMMANDS	CLIMB/DIVE	CLIMB/DIVE AND TURNS

ACAS/BCAS - LIMITATIONS

PROBLEM - EXCESSIVE ALARMS IN HIGH DENSITY TERMINAL AREAS

STUDIES:

1. NAFEC SIMULATION CHICAGO O'HARE PARALLEL
RUNWAY CONFIGURATION
2. NAFEC STUDY UTILIZING ARTS III TAPES OF O'HARE, LOS ANGELES,
MIAMI AND WASHINGTON

CONCLUSIONS:

1. THE PRESENT ESCAPE LOGIC (ANTC-117) PRODUCES EXCESSIVE
UNNEEDED ALARMS AROUND HIGH DENSITY AIRPORTS
2. SECONDARY ATC COMMANDS ARE INCREASED DUE TO UNWANTED
OR NEEDED CAS COMMANDS
3. LOGIC MUST BE MODIFIED FOR TERMINAL AREA
OPERATION (DESENSITIZED)
4. NEITHER ACAS OR BCAS WILL WORK IN TERMINAL AREA

COMPARISON OF ACAS & BCAS

ACAS

BCAS

**5. COOPERATIVE
ELEMENT
(PLUS
ENCODER)**

ACAS

**ATCRBS/DABS
TRANSPONDER**

**6. REGULATORY
ASPECTS
(PUBLIC
PASSENGER
PROTECTION)**

MANDATORY

**MANDATORY/
VOLUNTARY**

7. STATUS

**T&E COMPLETE DEVELOP-
MENTAL**

COMPARISON OF ACAS & BCAS

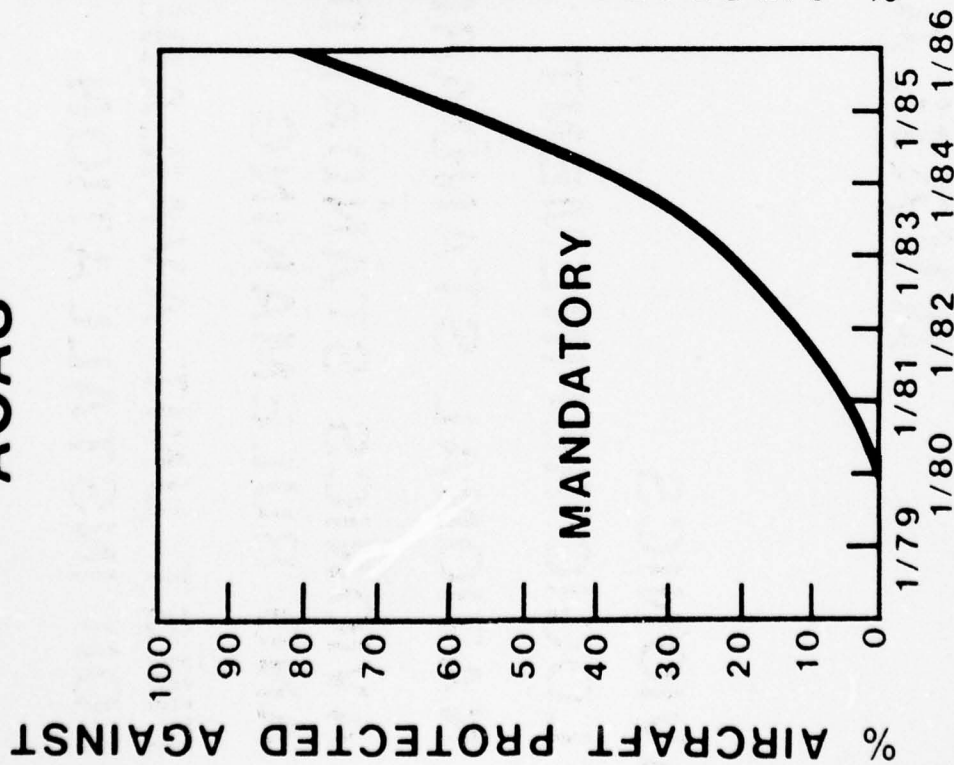
	ACAS	BCAS
8. AVAILABILITY		
AVIONICS	1/80	6/81
GROUND	NONE REQUIRED	NONE REQUIRED
9. WHEN		
PROTECTION	MID 1980's	MID 1980's
ACHIEVED		
10. UNIT COSTS (ELECTRONICS)		
AIR CARRIER	\$6,300	\$18,300
GENERAL		
AVIATION	\$930	
11. COST FOR PUBLIC		
PASSENGER	\$719M	\$307M
PROTECTION		

AVAILABILITY

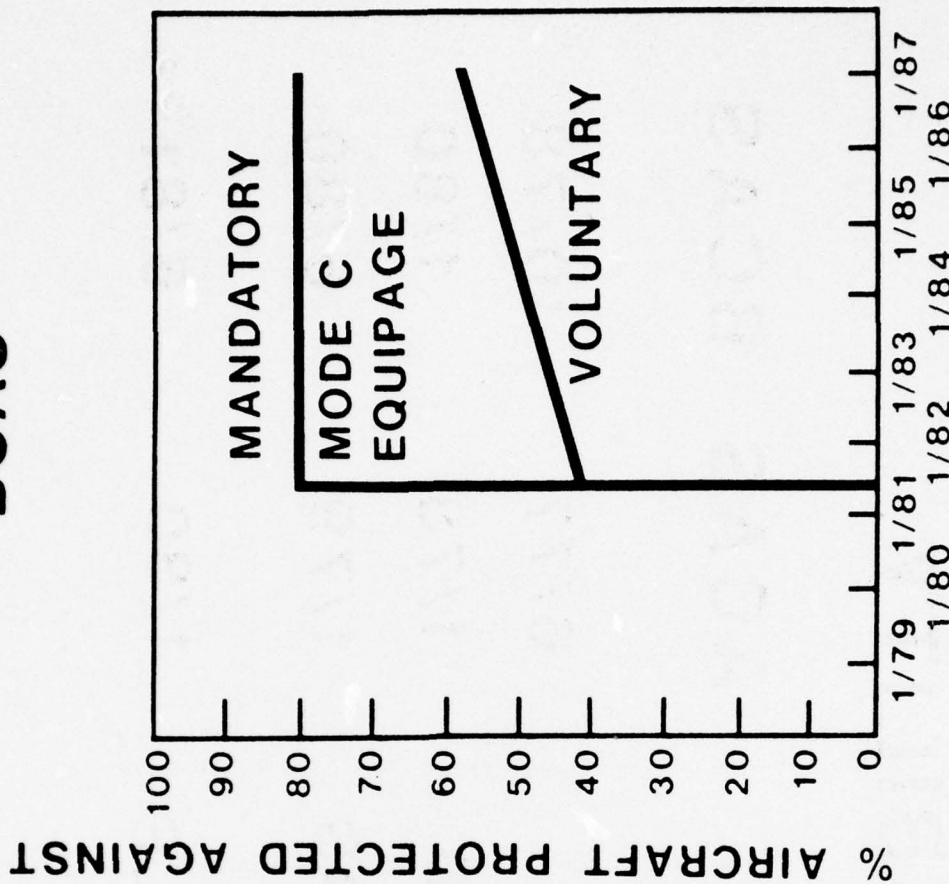
AVIONICS	ACAS	BCAS
LOGIC REFINEMENT	6/77	10/78
NATIONAL STANDARD	1/78	1/80
AVIONICS STANDARDS AND RULEMAKING	1/79	6/80
FIRST UNIT AVAILABLE FOR INSTALLATION	1/80	6/81

ACAS VS. BCAS PROTECTION

ACAS

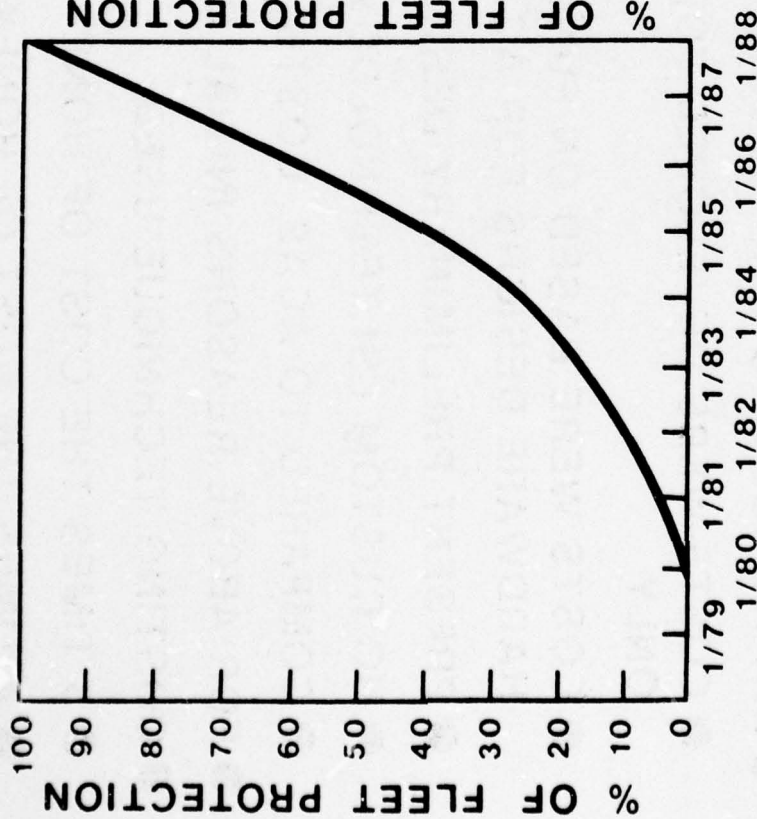


BCAS

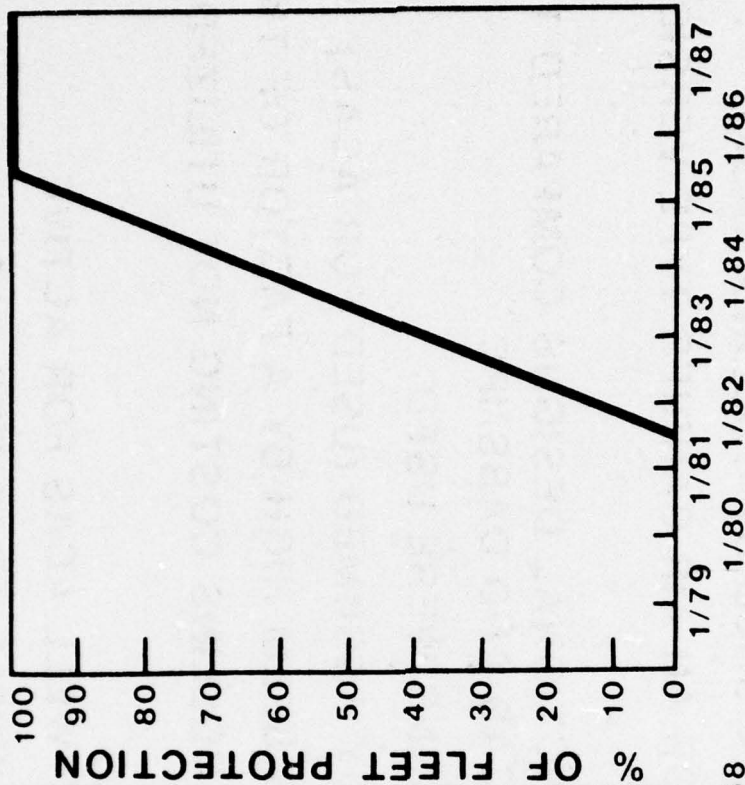


ACAS VS. BCAS PROTECTION

ACAS



BCAS



AIR CARRIER PROTECTION

ASSUMPTIONS

4 YEARS TO EQUIP AIR TRANSPORTATION

8 YEARS TO EQUIP GENERAL AVIATION AND MILITARY

COSTING ANALYSIS

- INITIAL COSTING WAS ACCOMPLISHED BY COLLINS RADIO
- COSTS WERE DEVELOPED FOR AN AIR CARRIER TYPE VERSION ONLY
- COSTS WERE BASED ON FUNCTIONAL DESIGNS COMPARED TO HARDWARE DESIGNS FOR ACAS AND DABS/IPC
- PRESENT PRELIMINARY DESIGNS WERE USED
- NO CUSTOM LSI TECHNOLOGY ASSUMED (USED FOR ACAS)
- COMPARED TO ACAS, COSTS SEEM HIGH BY A FACTOR OF TWO
- FOR ABOVE REASONS INITIAL COLLINS COSTING NOT UTILIZED
- COSTING TECHNIQUE USED
- 3 TIMES THE COST OF HONEYWELL ACAS FOR ACTIVE
- 4 TIMES THE COST OF HONEYWELL ACAS FOR PASSIVE/ACTIVE

BCAS AVIONICS COSTS

AIR CARRIER	ACTIVE	PASSIVE/ ACTIVE
BOX (1)	12,036	16,048
DISPLAY (2)	1,092	1,092
ANTENNA (2)	63	63
TOTALS	14,346	18,358

NOTE: () INDICATE NUMBER OF UNITS REQUIRED AND ARE
REFLECTED IN BOTTOM TOTAL

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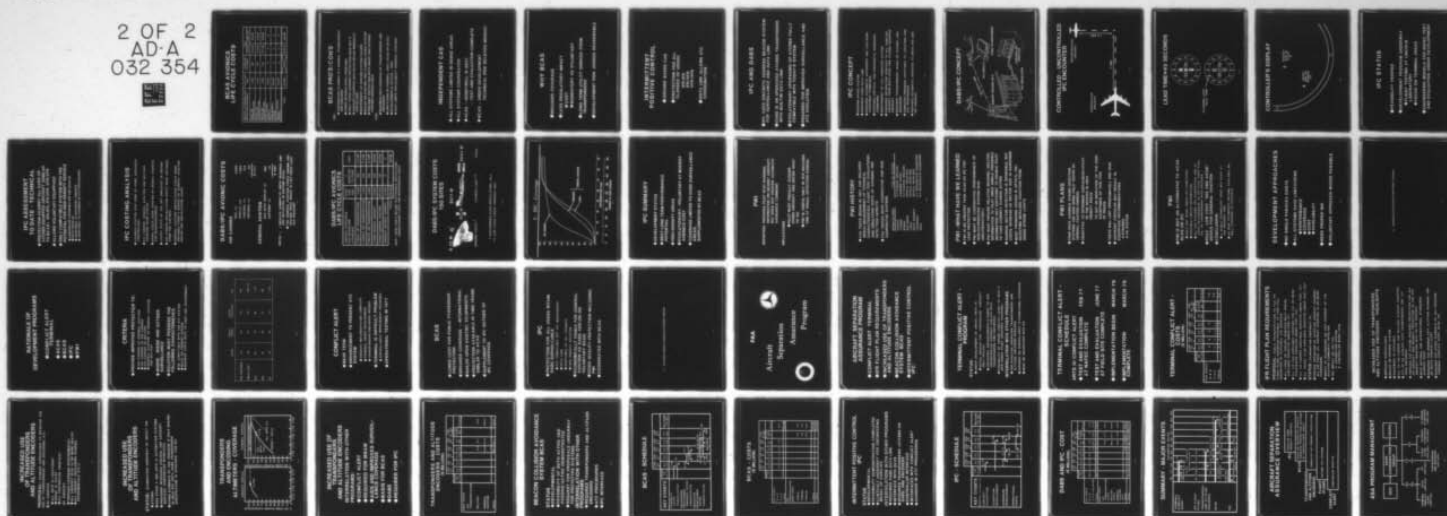
FEDERAL AVIATION ADMINISTRATION WASHINGTON D C ASSOC--ETC F/G 1/3
CONSULTATIVE PLANNING CONFERENCE ON AIRCRAFT SEPARATION ASSURAN--ETC(U)
SEP 76

UNCLASSIFIED

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DATE
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1-12-77
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BCAS AVIONICS LIFE CYCLE COSTS

AIRCRAFT CATEGORIES FOR SEPARATION ASSURANCE	FLEET SIZE 1985	% EXPECTED TO EQUIPT	COST	
			ACTIVE	PASS./ACT.
PUBLIC AIR TRANSPORTATION	4,900	100	\$ 94 M	\$113 M
FEDERAL AIR TRANSPORTATION	2,200	100	\$ 43 M	\$ 52 M
PRIVATE AIR TRANSPORTATION	6,000	100	\$111 M	\$142 M
OTHER FEDERAL AIRCRAFT	20,000	0	0	0
OTHER GENERAL AVIATION	189,400	0	0	0
AIRCRAFT WITHOUT AVIONICS	36,500	0	0	0
TOTAL	259,000		\$248 M	\$307M

BCAS PRO'S/CON'S

PRO

- COOPERATIVE ELEMENT IS A NORMAL TRANSPONDER AND ENCODER
- FEWER INTERNATIONAL PROBLEMS
- ONLY THOSE DESIRING PROTECTION NEED BUY IT
- AIRCRAFT EQUIPPED WITH BCAS OBTAIN IMMEDIATE PROTECTION
- INDEPENDENT OF GROUND SYSTEM FAILURE
- BUILDS ON EXISTING AND PLANNED (DABS) SYSTEM
- PROVIDES PROTECTION BOTH INSIDE AND OUTSIDE GROUND SURVEILLANCE

CON

- REQUIRES HIGH EQUIPAGE OF TRANSPONDERS AND ENCODERS
- LIMITATIONS IN TERMINAL AREA (ACAS OR BCAS)
- DEVELOPMENTAL STATUS -- RISK
- COST LIMITS APPLICABILITY (GENERAL AVIATION)

INDEPENDENT CAS

- ALL SYSTEMS LIMITED IN DENSE AREAS
- ALL SYSTEMS COOPERATIVE
- ACAS -- HONEYWELL IS BEST
 - TEST AND EVALUATION COMPLETE
- BCAS -- UNDER DEVELOPMENT
 - TECHNICAL RISK BELIEVED MODEST

WHY BCAS

- **BROADER COVERAGE**
- **LESS REGULATORY IMPACT**
 - **COST**
 - **MANDATORY VS VOLUNTARY**
- **LONG TERM UTILITY DERIVED FROM
TRANSPONDERS**
- **DEVELOPMENT RISK JUDGED REASONABLE**

INTERMITTENT POSITIVE CONTROL

- **GROUND BASED CAS**

- **PROTECTION FOR ALL
CLASSES OF USERS**

IFR/IFR

IFR/VFR

VFR/VFR

- **DATA LINK ALLOWS ATC
COORDINATION**

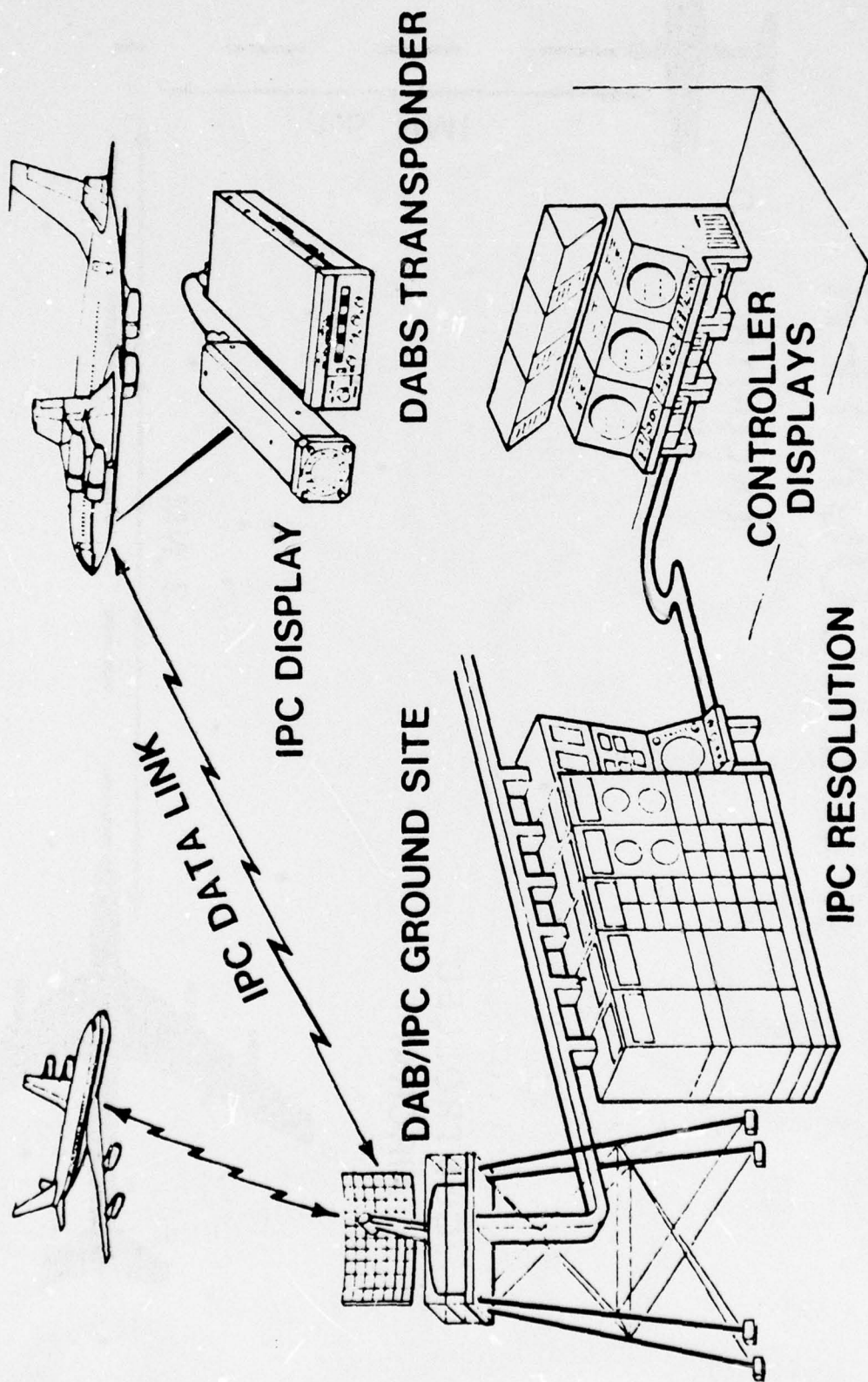
IPC AND DABS

- **IPC USES DISCRETE ADDRESS BEACON SYSTEM FOR SURVEILLANCE AND DATA LINK**
- **DABS IS AN UPGRADED ATCRBS TRANSPONDER WITH BUILT-IN DATA LINK**
- **EVOLUTIONARY UPGRADING OF ATCRBS FULLY COMPATIBLE WITH TODAY'S SYSTEM**
- **REQUIRED FOR IMPROVED SURVEILLANCE AND ATC EVOLUTION**

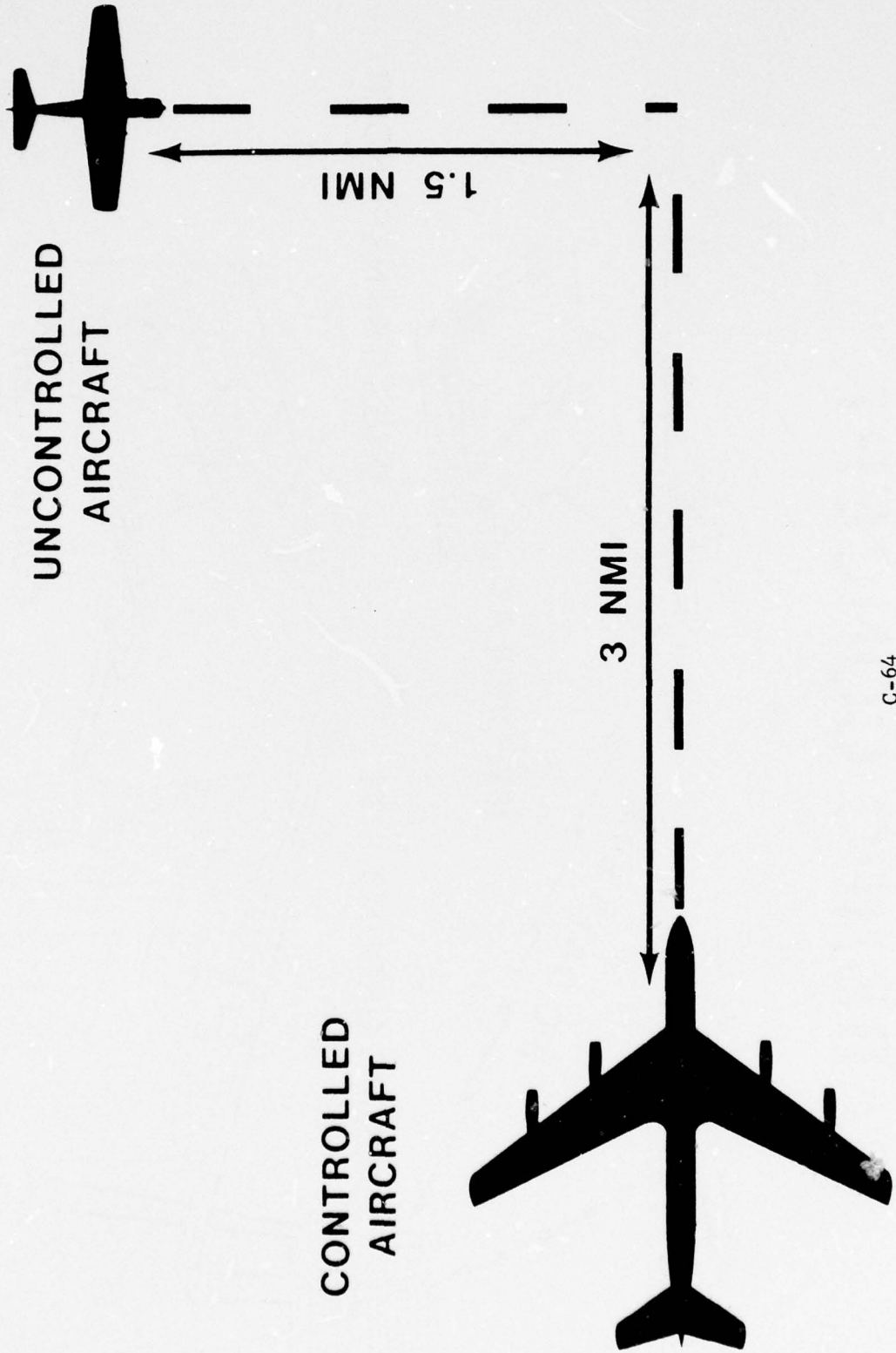
IPC CONCEPT

- GROUND BASED SYSTEM
- REQUIRES DABS DATA LINK
- PROVIDES AUTOMATIC ADVISORIES AND COLLISION AVOIDANCE COMMANDS
- PROVIDES VERTICAL AND HORIZONTAL MANEUVER COMMANDS
- INDEPENDENT OF ATC COMPUTER SYSTEM
- PROVIDES SEPARATION SERVICES TO ALL DABS/IPC AIRCRAFT FROM BOTH DABS AND ATCRBS EQUIPPED AIRCRAFT
- REQUIRES TRANSPONDERS (DABS OR ATCRBS) AND ENCODERS
- COMPUTER PROGRAM ADAPTABLE TO LOCATION AND ATC PROCEDURES
- PROVIDES AUTOMATIC SERVICES TO BOTH VFR AND IFR AIRCRAFT

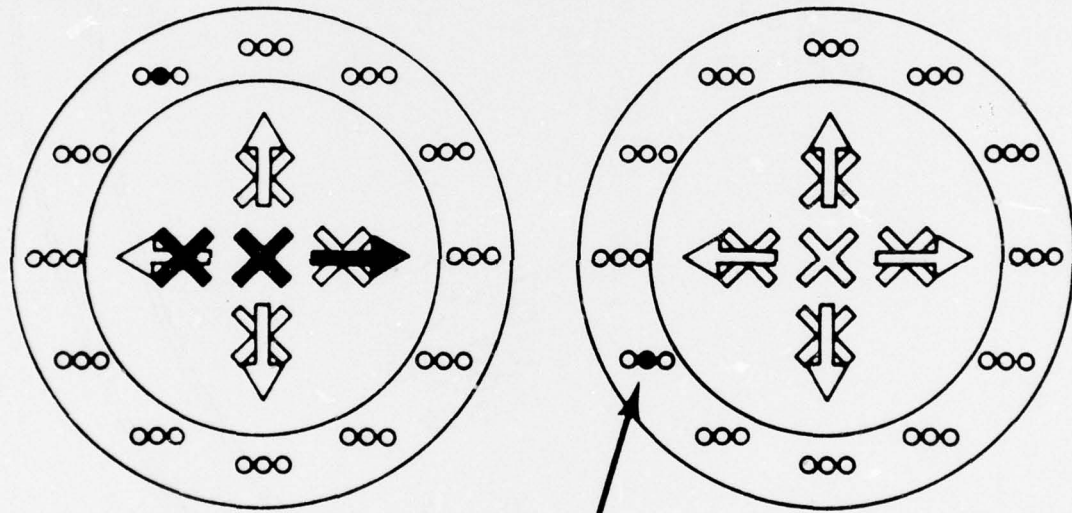
DABS/IPC CONCEPT



CONTROLLED - UNCONTROLLED IPC ENCOUNTER

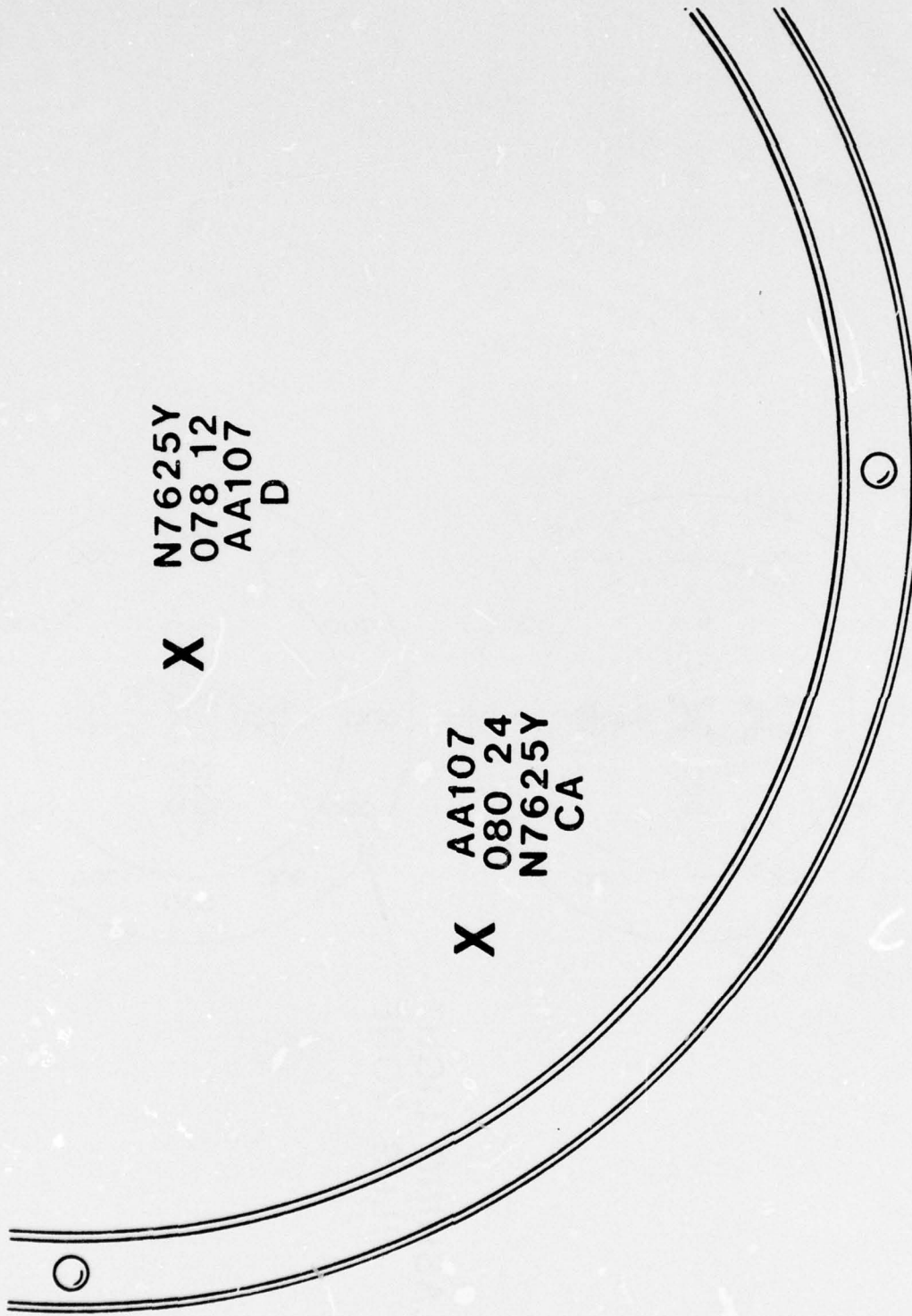


LEAD TIME=45 SECONDS



**FLASHING LIGHT
PLUS TONE**

CONTROLLER'S DISPLAY



IPC STATUS

- **FEASIBILITY VERIFIED**
- **DEVELOPMENT PROGRAM UNDERWAY**
 - **FLIGHT TESTING AT LINCOLN LABORATORY**
 - **FOCUS ON TERMINAL AREAS**
- **ENGINEERING MODELS FOR NAFEC TEST AND EVALUATION UNDER DEVELOPMENT**

IPC ASSESSMENT TO DATE - TECHNICAL

- **PROTECTION AGAINST ALL DABS OR ATCRBS EQUIPPED AIRCRAFT (SIMILAR TO BCAS). IFR/IFR, IFR/VFR, VFR/VFR**
- **ALLOWS VOLUNTARY EQUIPPAGE**
- **ONLY COMPATIBLE SYSTEM WITH THE POTENTIAL FOR HIGH DENSITY SERVICE**
 - **CONTROLLER COORDINATION AND BACK-UP**
 - **PILOT BACK-UP**
 - **ADAPTABLE TO DIFFERENT AIRPORTS**
 - **ADAPTABLE TO CHANGES IN ATC PROCEDURES**

IPC COSTING ANALYSIS

- AVIONICS COSTING WAS DONE BY ARINC RESEARCH CORPORATION
- AIR CARRIER, GENERAL AVIATION AND MILITARY VERSIONS WERE COSTED
- ARINC COSTS WERE VERIFIED BY BENDIX AVIONICS FOR REASONABLENESS
- LATEST STATE OF THE ART EMPLOYED IN DESIGN
- AIR CARRIER INSTALLATION COSTS WERE OBTAINED FROM THE AIRLINES
- GENERAL AVIATION INSTALLATION COSTS WERE OBTAINED FROM A SURVEY OF GENERAL AVIATION REPAIR AND INSTALLATION SHOPS

DABS/IPC AVIONIC COSTS

AIR CARRIER

BOX (1)	4,860
DISPLAY (2)	1,066
CONTROL (1)	516
ANTENNA (1)	63
	<hr/>
	\$7,571

GENERAL AVIATION

BOX WITH DISPLAY (1)	986
ANTENNA (1)	13
	<hr/>
	\$ 999

NOTES: () INDICATE NUMBER OF UNITS REQUIRED AND
ARE REFLECTED IN BOTTOM TOTAL

- THE GENERAL AVIATION COSTS SHOWN ARE
SELLING PRICE WHICH IS LIST PRICE LESS
20% DISCOUNT

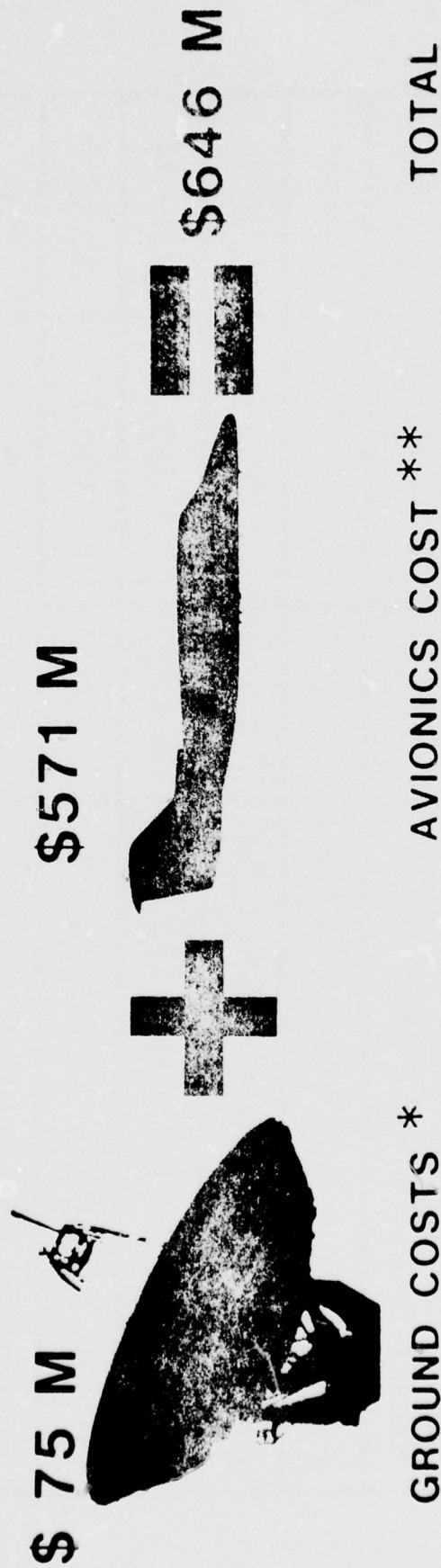
DABS/IPC AVIONICS LIFE CYCLE COSTS

AIRCRAFT CATEGORIES FOR SEPARATION ASSURANCE	FLEET SIZE 1985	% EXPECTED TO EQUIP	COST
PUBLIC AIR TRANSPORTATION	4,900	100	\$ 63M
FEDERAL AIR TRANSPORTATION	2,200	100	\$ 22M
PRIVATE AIR TRANSPORTATION	6,000	100	\$ 60M
OTHER FEDERAL AIRCRAFT	20,000	100	\$191M
OTHER GENERAL AVIATION	189,400	100	\$235M
AIRCRAFT WITHOUT AVIONICS	36,500	0	0
TOTAL	259,000		\$571M

NOTE: THESE COSTS INCLUDE ELECTRONICS, INSTALLATION,
NONRECURRING COSTS AND MAINTENANCE COSTS

DABS/IPC SYSTEM COSTS

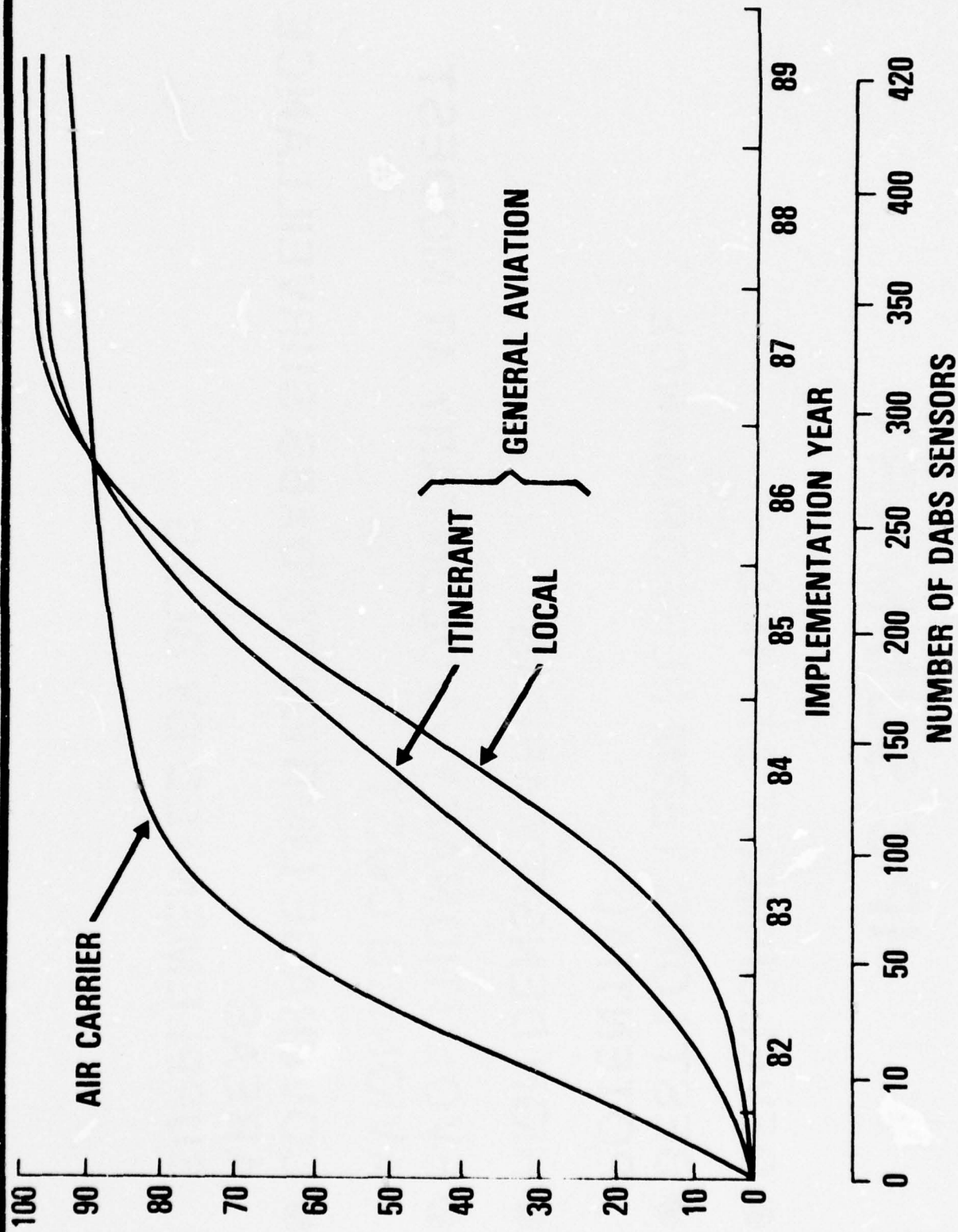
150 SITES



* ELECTRONICS PLUS INSTALLATION ONLY

** LIFE CYCLE COSTS THROUGH 1985

V. IPC - Coverage



IPC SUMMARY

- **DEVELOPMENT STATUS**
- **BEST LONG TERM PERFORMANCE
POTENTIAL**
- **HIGH DENSITY AREAS**
- **EVOLUTIONARY - VOLUNTARY AT MODEST
AVIONICS COST**
- **COVERAGE LIMITED TO DABS SURVEILLANCE
AREAS.
SUPPLEMENTED BY BCAS**

PWI

**DEFINITION: PROVIDES PILOT WITH WARNING
INFORMATION ON NEARBY AIRCRAFT,
BUT DOES NOT PROVIDE AUTOMATIC
AVOIDANCE COMMAND**

IMPLICATIONS

- **PILOT MUST VISUALLY ACQUIRE
OTHER AIRCRAFT AND DECIDE WHAT
TO DO**
- **PWI IS USEFUL ONLY IN VFR WEATHER
AND AT VISUAL DETECTION RANGES**

PWI HISTORY

- FAA TESTS BEGAN IN 1967 AND INCLUDED BENCH MEASUREMENT OF TECHNICAL CHARACTERISTICS, FLIGHT TEST EVALUATIONS, AND SIMULATION TESTS OF WARNING AND DETECTION ASPECTS
- FAA TESTED BOTH COOPERATIVE AND NON COOPERATIVE SYSTEMS

<u>MANUFACTURER</u>	<u>TYPE OF SYSTEM</u>
GENAVE	R-F PASSIVE (BEACON)
CYGNED	AIRBORNE RADAR
BENDIX	R-F PASSIVE (BEACON)
KOLLSMAN	OPTICAL INFRA-RED
LORAL	OPTICAL INFRA-RED
ROCK AVIONICS	OPTICAL INFRA-RED
LOCKHEED	R-F INTERROGATE-TRANSPOND
VEGA	R-F INTERROGATE-TRANSPOND

PWI -WHAT HAVE WE LEARNED

- PWI IS NO CHEAPER THAN ACAS OR IPC FOR LESS PROTECTION
- PWI MUST BE COOPERATIVE (PERFORMANCE OF NON-CO-OPERATIVE SYSTEM WAS UNSATISFACTORY)
- PWI MUST PROVIDE RELATIVE BEARING (SECTOR) INFORMATION TO PILOT SINCE SIMPLE PRESENCE INFORMATION NOT SUFFICIENT TO ENABLE PILOT TO TAKE CORRECT EVASIVE ACTION
- NARROW SECTOR DETECTION IS DESIRABLE, BUT COSTS INCREASE AS SECTOR SIZE IS NARROWED
- MOST PROMISING DESIGN IS OPTICAL PWI DETECTING INFRA-RED RADIATION FROM XENON STROBE LIGHTS

PWI PLANS

- **FOUR ROCK AVIONICS STROBE DETECTION SYSTEMS ARE NOW BEING FIELD TESTED BY GENERAL AVIATION OWNERS**
- **OBJECTIVE: TO DETERMINE USEFULNESS/UTILITY OF THE DEVICES IN HIGH DENSITY AREAS**
TO GET AN INDICATION OF THE USER ACCEPTANCE OF THIS TYPE OF DEVICE
- **TESTS WILL LAST APPROXIMATELY ONE YEAR**
- **ADVISORY CIRCULAR MAY RESULT IN EQUIPPAGE RECOMMENDATIONS**
 - **STROBES**
 - **I/R SYSTEM**

PWI

● PWI IS NOT AN ALTERNATIVE TO ACAS, BCAS OR IPC

- DOES NOT WORK UNDER IFR CONDITIONS
- PROVIDES LIMITED INFORMATION
- ALL PWI SYSTEMS ARE COOPERATIVE AND AT
LEAST AS EXPENSIVE AS AN ACAS, DABS PLUS
IPC, OR TRANSPONDER WITH ENCODER

● ROLE - LOW COST "SEE AND AVOID" DEVICE FOR GENERAL AVIATION

● CONCLUSION

- A VIABLE TECHNOLOGY DOES NOT EXIST AT
THE PRESENT TIME
- AS NEW TECHNIQUES BECOME AVAILABLE WE
WILL CONTINUE TO EVALUATE

DEVELOPMENT APPROACHES

- **NO SINGLE PANACEA EXISTS**
- **ALL SYSTEMS HAVE LIMITATIONS**
 - **PERFORMANCE**
 - **COVERAGE**
 - **COST**
 - **AVAILABILITY**
- **NEED PROPER MIX**
- **VOLUNTARY APPROACH WHERE POSSIBLE**

D. COMPARISON OF OVERLAPPING DEVELOPMENT PROGRAMS

RATIONALE OF DEVELOPMENT PROGRAMS

● **CONFLICT ALERT
(TERMINAL)**

● **ACAS**

● **BCAS**

● **IPC**

● **PWI**

CRITERIA

● PROVIDE IMPROVED PROTECTION TO:

- AIR CARRIER VS GENERAL AVIATION
- AIR CARRIER VS AIR CARRIER
- AIR CARRIER VS MILITARY
- GENERAL AVIATION VS GENERAL AVIATION
AND MILITARY

● WHERE - INSIDE AND OUTSIDE SURVEILLANCE

● SOLUTION MUST POSSESS THE FOLLOWING CHARACTERISTICS

- BE COMPATIBLE WITH THE ATC SYSTEM
- BUILD ON PRESENT SYSTEM
- MINIMIZE COSTS BOTH TO USER AND GOVERNMENT

	AIRPORT	ENROUTE/ TERMINAL	REQUIRES SURVEILLANCE	TIME
MORE TRANSPONDERS	YES	YES	YES	NOW
CONFLICT ALERT	YES	YES	YES	NOW/1 YR.
ECAS	NO	YES	NO	2 YRS.
ACAS	NO	YES	NO	NOW
IPC	YES	YES	YES	5 YRS.

CONFLICT ALERT

- **NEAR TERM**
- **ENHANCEMENT TO PRESENT ATC SYSTEM**
 - **ENROUTE IMPLEMENTATION COMPLETE**
 - **TERMINAL UNDER DEVELOPMENT**
 - **TRANSPONDERS/ENCODERS NEEDED**
- **TERMINAL IS DIFFICULT PROBLEM**
 - **SURVEILLANCE IMPROVEMENT DESIRABLE**
- **OPERATIONAL TESTING IN 1977**

BCAS

- **LOWER COST FOR PUBLIC PASSENGER PROTECTION**
- **BROADER COVERAGE -- INTERNATIONAL**
- **BUILDS UPON EXISTING EQUIPMENTS**
- **PROTECTION AVAILABLE IN TIME FRAME SIMILAR TO ACAS**
- **SUPPLEMENT TO IPC OUTSIDE OF IPC COVERAGE**

IPC

- PROTECTION FOR ALL USERS WITHIN DABS SURVEILLANCE
 - ATC COMPATIBLE BUT YET INDEPENDENT
 - DATA LINK
 - ADAPTABLE TO ALL CHANGES
 - HIGH DENSITY SOLUTION
- ECONOMICALLY VIABLE FOR GENERAL AVIATION AS DABS ADD-ON ON VOLUNTARY BASIS
- GOOD QUALITY PROTECTION INCLUDING PWI
- COOPERATES WITH BCAS

E. FIVE-POINT AIRCRAFT SEPARATION ASSURANCE PROGRAM

FAA

Aircraft Separation

Assurance Program



AIRCRAFT SEPARATION ASSURANCE PROGRAM

- **CONFLICT ALERT (TERMINAL)**
- **IFR FLIGHT PLAN REQUIREMENTS**
- **INCREASED USE OF TRANSPONDERS
AND ALTITUDE ENCODERS**
- **BEACON COLLISION AVOIDANCE
SYSTEM (BCAS)**
- **INTERMITTENT POSITIVE CONTROL
(IPC)**

TERMINAL CONFLICT ALERT - PROGRAM

STATUS:

- UNDER DEVELOPMENT BY UNIVAC (ARTS III)
- INITIAL SERVICE FOR "CONTROLLED" AIRCRAFT ONLY (IFR/IFR)
- ADDITIONAL ENHANCEMENTS PLANNED TO ADD UNCONTROLLED AIRCRAFT (IFR/VFR WITH TRANSPONDERS AND ENCODERS)
- POSSIBILITY OF ADDING CONFLICT ALERT TO ARTS II NOW UNDER STUDY (REQUIRES TRACKING)

INTERRELATION WITH OTHER PROGRAMS

- FOR EFFECTIVE OPERATION TRANSPONDERS AND ALTITUDE ENCODERS REQUIRED
- DEPENDS ON SURVEILLANCE (ATCRBS/DABS) COVERAGE
- MUST BE INTERFACED WITH IPC

TERMINAL CONFLICT ALERT - SCHEDULE

ARTS III CONFLICT ALERT

● TEST AND EVALUATION FEB 77
AT NAFEC COMPLETE

● TEST AND EVALUATION JUNE 77
AT FIELD SITE COMPLETE

● IMPLEMENTATION BEGIN MARCH 78

**● IMPLEMENTATION
COMPLETE MARCH 79**

TERMINAL CONFLICT ALERT - **COSTS** **(\$ MILLION)**

	JAN 76JAN 77JAN 78JAN 79JAN 80JAN 81 - 85							TOTALS
	PRIOR TO FY-76	FY -76	FY -77	FY -78	FY -79	FY -80	FY-81 THRU 85	
FAA COSTS		.3	.6	.5	.2			1.6
R & D		.1	.1	1.7	1.7			3.6
F & E		.4	.7	2.2	1.9			5.2
TOTAL								

IFR FLIGHT PLAN REQUIREMENTS

PROPOSAL: PUBLIC TRANSPORTATION TO FILE IFR FLIGHT PLANS WHENEVER POSSIBLE, TO TAKE FULL ADVANTAGE OF AVAILABLE ATC SERVICES

- ALL LARGE OR TURBINE POWERED MULTI ENGINE AIRPLANES OPERATED UNDER PART 91?
- ALL AIR TAXI AIRPLANES CARRYING TEN (10) OR MORE PASSENGERS OPERATED UNDER PART 135?
- ALL AIR CARRIER AIRPLANES OPERATED UNDER PART 121?
- ALL TRAVEL CLUB AIRPLANES OPERATED UNDER PART 123?

STATUS: EXAMINATION UNDERWAY OF:

- PRECISE DEFINITION OF AFFECTED AIRCRAFT SEGMENT:
ALL AIR TAXIS, ALL AIRCRAFT CARRYING 10 OR MORE PASSENGERS

- IMPACT OF RULEMAKING ON THAT SEGMENT OF THE AVIATION COMMUNITY AFFECTED

- THE IMPACT ON THE FAA
 - A AUTOMATION SYSTEM
 - B CONTROLLER WORK LOAD

INCREASED USE OF TRANSPONDERS AND ALTITUDE ENCODERS - HIGHLIGHTS

- IMPROVES SURVEILLANCE
- BUILDS ON PRESENT SYSTEM
- EQUIPMENT IS AVAILABLE
- ALL OF AIR CARRIER AND MILITARY ALREADY EQUIPPED
- 70% OF GA ALREADY HAVE TRANSPONDERS AND 10%
HAVE ENCODERS
- THROUGH ATC SYSTEM PROVIDES PROTECTION FOR ALL
IFR AIRCRAFT AND INDIRECT PROTECTION TO THE VFR
AIRCRAFT INVOLVED WITH AN IFR AIRCRAFT
- BOTH NATIONAL AND INTERNATIONAL STANDARDS
ALREADY EXIST
- REQUIRED FOR MINIMUM SAFE ALTITUDE WARNING AND
EN ROUTE CONFLICT ALERT
- REQUIRED FOR OTHER ELEMENTS OF ASA PROGRAM:
TERMINAL CONFLICT ALERT, BCAS, IPC

INCREASED USE OF TRANSPONDERS AND ALTITUDE ENCODERS

**PROPOSAL: EXAMINE APPROACHES TO INCREASE THE
USE OF TRANSPONDERS AND ENCODERS, E.G.,**

● BY AIRSPACE

- ALL ARTS III LOCATIONS?
- GROUP III TCA'S?
- ALL CONTROLLED AIRSPACE?

BY AIRCRAFT

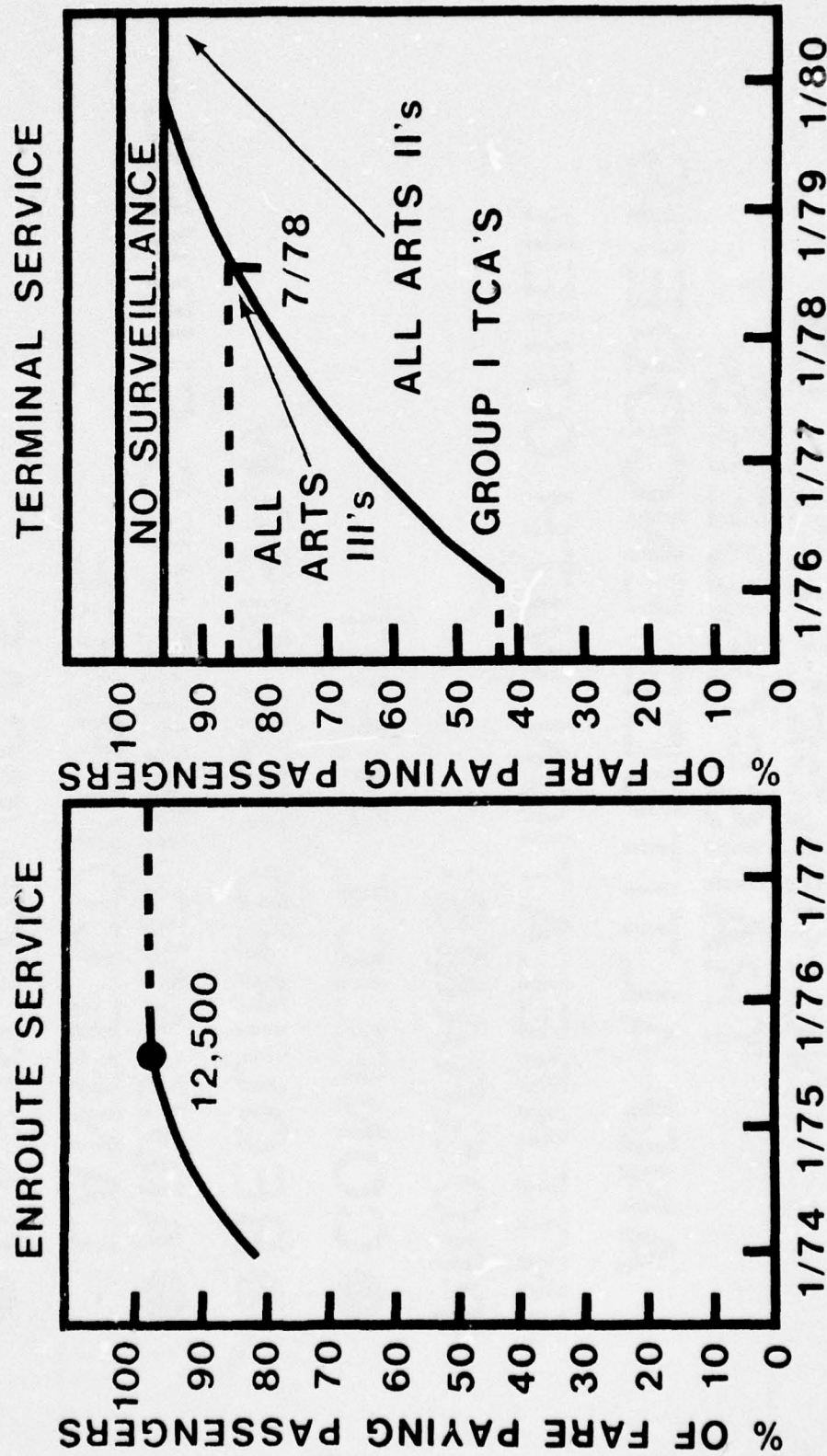
- THROUGH LICENSING REQUIREMENTS?
- ALL AIRCRAFT WITH 10 OR MORE SEATS?
- ALL AIRCRAFT (EXCLUDING GLIDERS,
EXPERIMENTALS ETC.)?

INCREASED USE OF TRANSPONDERS AND ALTITUDE ENCODERS

STATUS: EXAMINATION UNDERWAY OF IMPACT ON:

- **ATCRBS**
- **NAS STAGE A AND ARTS III AUTOMATION SYSTEMS**
- **PROVIDING INCREASED CONTROL AND ADVISORY SERVICES (CONTROLLER WORKLOAD)**
- **OTHER ELEMENTS OF ASA PROGRAM IF RULE MAKING IS HELD OFF UNTIL DABS TRANSPONDER SPECIFICATION IS AVAILABLE (JAN 80)**

TRANSPONDERS AND ENCODING ALTIMETERS - COVERAGE



INCREASED USE OF TRANSPONDERS AND ALTITUDE ENCODERS

**INTERRELATION WITH OTHER
PROGRAMS:**

- **CONFLICT ALERT**
- **REQUIRED FOR MSAW**
- **AIDS AND IMPROVES SURVEIL-
LANCE COVERAGE**
- **BASIS FOR BCAS**
- **DABS**
- **REQUIRED FOR IPC**

TRANSPONDERS AND ALTITUDE ENCODERS - COSTS (\$ MILLION)

	PRIOR TO FY-76	JAN 76	JAN 77	JAN 78	JAN 79	JAN 80	JAN 81 - 85	TOTALS
		FY -76	FY -77	FY -78	FY -79	FY -80	FY-81 THRU 85	
USER COSTS								
AIR								
TRANSPORTATION								
MILITARY					5.5	3.7		9.2
GENERAL					42.6	41.4		84.0
AVIATION								
TOTAL					48.1	45.1		93.2

BEACON COLLISION AVOIDANCE SYSTEM (BCAS)

STATUS

● DEVELOPMENTAL

**● FEASIBILITY OF BOTH ACTIVE AND
PASSIVE/ACTIVE DEMONSTRATED**

**● REQUEST FOR PROPOSALS UNDERWAY
FOR PROTOTYPE SYSTEMS**

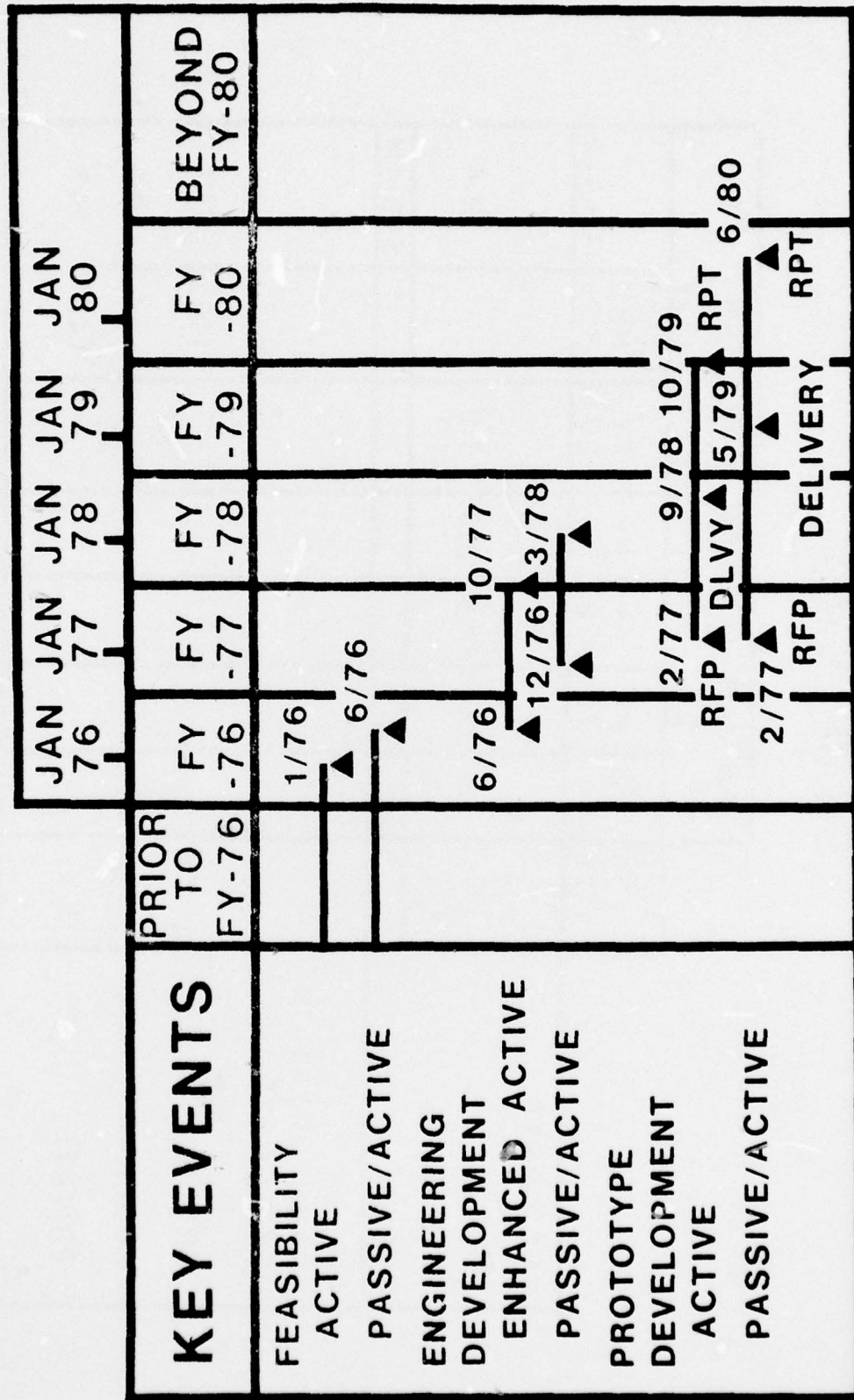
INTERRELATION WITH OTHER PROGRAMS

**● REQUIRES TRANSPONDERS AND ALTITUDE
ENCODERS**

● ATC PROCEDURES

● IPC INTERFACE

BCAS - SCHEDULE



BCAS - COSTS

(\$ MILLION)

	JAN 76	JAN 77	JAN 78	JAN 79	JAN 80	JAN 81 - 85	
	FY -76	FY -77	FY -78	FY -79	FY -80	FY-81 THRU 85	TOTALS
FAA COSTS							
R & D	1.1	5.4	7.5	3.5	1.9		19.4
F & E							
TOTAL							\$19.4M
AIR							
TRANSPORTATION						113	113
USER COSTS						52	52
PUBLIC						142	142
FEDERAL							
PRIVATE							
TOTAL							\$307M
TOTAL							\$326M

INTERMITTENT POSITIVE CONTROL (IPC)

STATUS

- **DEVELOPMENTAL**
- **FEASIBILITY DEMONSTRATION COMPLETED**
- **CONTRACT UNDERWAY FOR ENGINEERING
MODEL OF DABS/IPC**

INTERRELATION WITH OTHER PROGRAMS

- **REQUIRES DABS DATA LINK**
- **INTERFACE WITH BCAS**
- **REQUIRES TRANSPONDERS (ATCRBS OR
DABS) AND ENCODERS**
- **CONTROLLER INTERFACE**
- **INTERFACES WITH CONFLICT ALERT**
- **CHANGES IN ATC PROCEDURES**

IPC - SCHEDULE

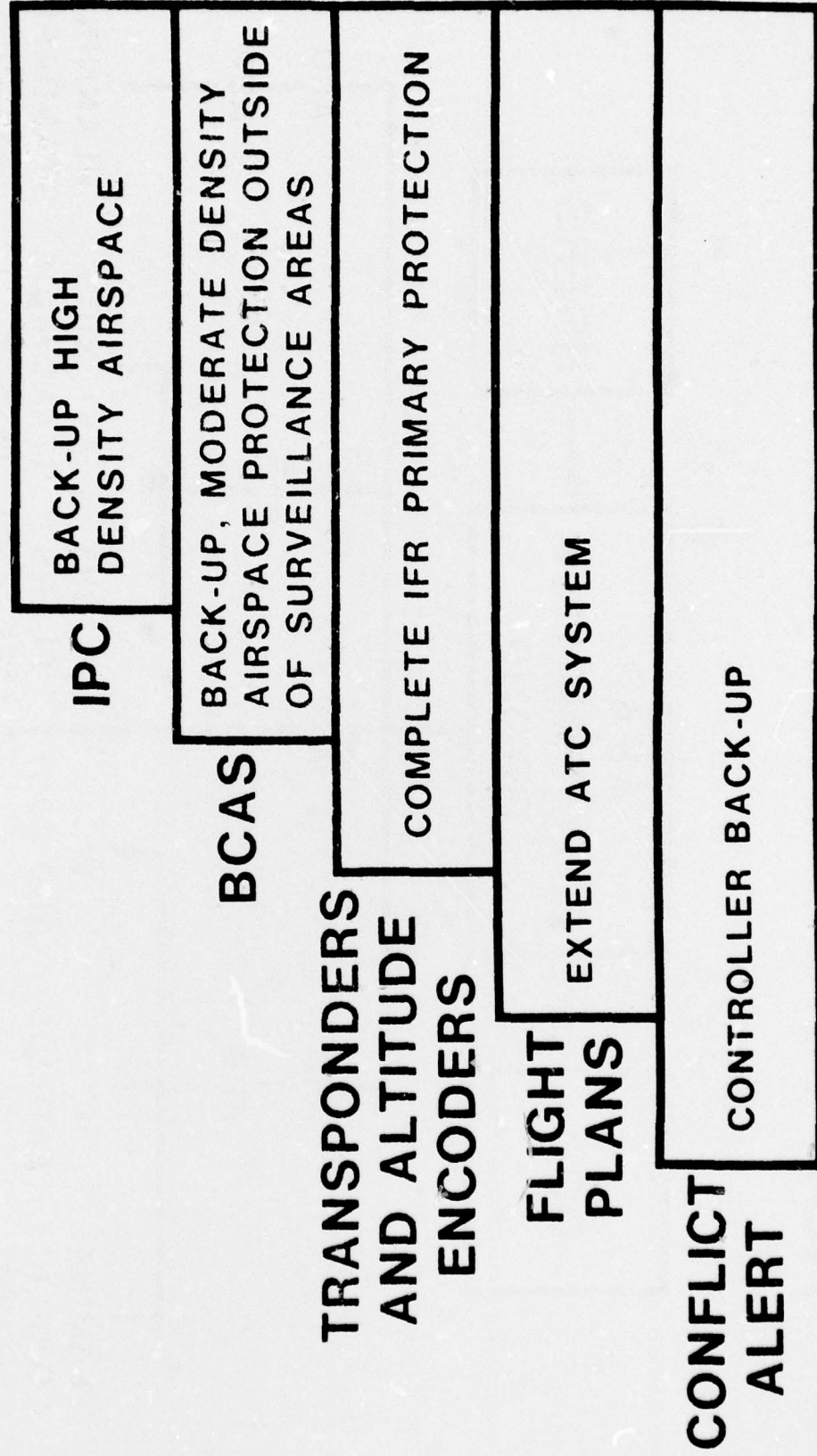
KEY EVENTS	PRIOR TO FY-76	JAN 76	JAN 77	JAN 78	JAN 79	JAN 80	BEYOND FY-80
		FY -76	FY -77	FY -78	FY -79	FY -80	
CONCEPT VALIDATION	— ▲	2/76					
ALGORITHM DEVELOPMENT	—				5/79 ▲		
HARDWARE DEVELOPMENT		2/76 ▲	11/77 ▲	DLVY	5/79 ▲	SPEC	
OPERATIONAL TESTS			12/77 ▲			10/79 ▲	

DABS AND IPC - COST

(\$ MILLION)

	PRIOR TO FY-76	JAN 76	JAN 77	JAN 78	JAN 79	JAN 80	JAN 81 -85	TOTALS
FAA COSTS		FY -76	FY -77	FY -78	FY -79	FY -80	FY-81 THRU 85	
R & D	20.4	8.2	15.8	13.5	7.8	4.2	1.3	71.2
F & E (150 SITES)					5.0	20.0	50.0	75.0
TOTAL	20.4	8.2	15.8	13.5	12.8	24.2	51.3	146.2
USER COSTS								
AIR						15.6	47.7	63.3
TRANSPORTATION (100%)						40.7	172.1	212.8
MILITARY (100%)						15.6	72.9	88.5
GENERAL AVIATION (30%)					0.0	71.9	292.7	364.6
TOTAL	20.4	8.2	15.8	13.5	12.8	96.1	344.0	\$510.8

AIRCRAFT SEPARATION ASSURANCE OVERVIEW



ASA PROGRAM MANAGEMENT

